UNDERSTANDING MIDDLE AND HIGH SCHOOL MATHEMATICS TEACHERS' ATTITUDES TOWARDS AND USE OF TECHNOLOGY

by

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DEDICATION

This dissertation is dedicated to my husband, Trevor, and my children, Tirzah and Micah, who have provided the support, encouragement, and love needed throughout this process.

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ABSTRACT

While many educators are consistently searching for ways to use technology for teaching and learning as new technologies emerge and older technologies are improved, not all are enthusiastic about the changes (Dobo, 2016). There is a positive correlation between teachers' beliefs about the effectiveness of technology and its use in the classroom (Petko, 2012). Teachers who have positive beliefs about technology tend to use it more in their classrooms. This mixed-method study seeks to answer the question of how do secondary mathematics teachers' use of technology in the classroom reflects their attitudes towards technology and its use. The first sub-question of what are the attitudes of secondary school mathematics teachers towards technology in the classroom as measured by the Teachers' Attitudes Toward Computers (TAC) Questionnaire is addressed in the quantitative phase through the questionnaire responses of twenty-eight middle and high school mathematics teachers in a small, rural public school system in the Mid-Atlantic region of the United States (Christensen & Knezek, 2009). The second sub-question of how is the technology used in secondary school mathematics classrooms when viewed through the lens of the RAT framework is addressed in the qualitative phase through interviews with eight of the participants from the quantitative phase (Hughes et al., 2006). The twenty-eight participants' overall attitudes towards technology were positive with the lowest in interaction and absorption and the highest in accommodation and significance. The majority of the uses of technology for the interview participants were coded as instructional methods and amplification, which

reflects the participants' positive attitudes towards technology, particularly in accommodation, significance, utility, interest, and perception while the lower percentage of uses coded as student learning processes and transformation could reflect their less positive attitudes with regard to comfort, concern, absorption, and interaction. As teachers' attitudes towards technology improve, the use of technology for student learning processes at the transformational level may also increase.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CCSS	Common Core State Standards
CK	Content Knowledge
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
RAT	Replacement-Amplification-Transformation
SAMR	Substitution-Augmentation-Modification-Replacement
TAC	Teachers’ Attitudes Toward Computers
TCK	Technological Content Knowledge
TPACK	Technological, Pedagogical, and Content Knowledge
TPK	Technological Pedagogical Knowledge

CHAPTER ONE: INTRODUCTION

As new technologies emerge and older technologies are improved, schools and school systems are finding ways to obtain and use new technology for teaching and learning (Dobo, 2016). An increasing number of school districts are implementing 1:1 programs (Cole & Sauers, 2018). According to the Glossary of Education Reform, "the term one-to-one is applied to programs that provide all students in a school, district, or state with their own laptop, netbook, tablet computer, or other mobile-computing device" (One-to-One Definition, 2013, para. 1). Some programs allow students to take the devices home to complete assignments, while others only provide the devices inside the school building. These programs are not always successful or may struggle to succeed in the first stages of implementation. There are many reasons for the success or failure of these initiatives. One major contributor is the teachers' attitudes toward and perceptions of the integration of technology into their classrooms (Tomlinson, 2015). While there is little research regarding teachers' attitudes towards technology in the mathematics classroom, Minshew and Anderson (2015) found that the methods and reasons for technology integration in the middle and high school mathematics classroom vary among teachers. Some teachers may find it very easy to integrate technology, while others could be uncomfortable using it.

When the reasons for the decisions on how technology is integrated into the classroom are known, actions can be taken to address them. The Replacement-Amplification-Transformation (RAT) model (Hughes, Thomas, & Scharber, 2006) is used to assess the level of technology integration focusing on three aspects of the classroom: instructional methods, student learning processes, and curriculum goals. The RAT model has been used to study teachers' technology integration levels. For example, Hsieh and Tsai (2017) used the model to analyze qualitative data regarding fifteen senior high school teachers' conceptions of mobile learning from five schools in northern Taiwan involved in a national mobile learning program. A mixed methods research design was used by Kimmons, Miller, Amador, Desjardins, and Hall (2015) to study the relationship between the course performance tasks and pre-service teachers' technology integration learning outcomes. They collected survey and performance task reflection data from undergraduate students in a public university education program in four sections of an educational technology course. The RAT model was used to analyze the data to determine if there are some technology-specific performance tasks that are more likely to lead pre-service teachers to think about technology integration in specific ways.

Three studies that involve the mathematics classroom were qualitative studies. The framework was used by Hughes, Ko, and Boklage (2017) in a descriptive, multiple case study to assess the technology-supported practices used by two mathematics and two science teachers who integrated iPads in STEM courses. Ardic and Isleyen (2017) used the RAT model in a qualitative study to compare three high school math teachers' technology integration before and after in-service training on the use of specific mathematics software. Bozkurt, Demir, and Vural (2014) investigated the effect of professional development on technology integration in mathematics classrooms through a qualitative analysis of video-recorded lessons. In addition, they used the RAT framework to analyze the changes technology integration levels before and after the training and the effect of these changes on students' learning.

This study will examine how middle and high school mathematics teachers integrate technology into their classrooms, as well as how their technology integration reflects their attitudes towards technology by using quantitative data from a questionnaire to evaluate the teachers' attitudes and qualitative data from interviews to analyze their technology integration, using the RAT framework. This study will help to close the gap of research understanding links between middle and high school mathematics teachers' attitudes and their technology integration.

Background of the Study

Technology is constantly changing. As school systems work to increase the availability and use of technology to provide relevant education for their students, obstacles arise that may hinder the integration of technology in the classroom. Administrators and educators can make decisions that will best fit the needs of the teachers and students in their school systems by understanding these barriers and how they affect the use (or lack of use) of technology.

First-order barriers are external to the teacher and typically out of the control of the individual teacher. These barriers affect the entire population and must be addressed for the diffusion of the innovation to occur. Vongkulluksn, Xie, and Bowman (2018) categorized these barriers as resource and institutional. First-order barriers not only hinder technology integration in their own right but they can also have an effect on the second-order barriers, which are internal relating to the teacher's belief system (Vongkulluksn et al., 2018). Teachers who are innovators or early adopters will often address first-order barriers in their own classrooms. Leggett and Persichitte (1998) identified five obstacles, falling under first-order barriers, which prevent the implementation and integration of technology into classrooms: time, expertise, access, resources, and support.

Second-order barriers focus on the individual teacher and his or her personal interactions with and attitudes towards technology. These attitudes can be related to teachers' perceptions of first-order barriers. As Ertmer (1999) explains, second-order barriers may not be easily observed, however, the reasons teachers give for their frustration over first-order barriers often shows the presence of the second-order barriers. The first-order barriers need to be addressed in a way that will positively influence the second-order barriers. While first-order barriers can present considerable obstacles to technology integration, the relative strength of second-order barriers may amplify or lessen their effects (Ertmer, 1999).

Ertmer (1999) explains that second-order barriers are more deeply ingrained in the individual and less quantifiable so they can be more challenging to address. The degree to which these barriers affect a teacher's technology integration varies with each person. Vongkulluksn et al., (2018) categorized these barriers as knowledge and skills and attitudes and beliefs. The perceived benefit of technology in improving student learning and the teacher's estimation of his or her own technological skills are factors that affect the motivation of a teacher to use it (Petko, 2012). The confidence of the teacher in his or her own abilities to evaluate, select, use, and manage technology will affect the choice to integrate it into the classroom.

According to Hsu (2016), the best predictor of the way teachers will integrate technology into their classrooms is their beliefs about pedagogy, self-efficacy, and perceived value to student learning of the technology. The way a teacher views the learning process will affect his or her use of technology. Inan and Lowther (2010) found teacher belief is a critical factor in the decision to integrate technology and suggest that contextual factors such as administrative, technical, and parental support, as well as professional development and resources can positively impact teachers' beliefs. Teachers must believe the technology will be valuable to student learning in order to be willing to risk the time required to use it. Howard (2013) found that "resistance to technology may, in fact, be risk perception and uncertainty" which may not allow the teacher to view the technology as a potential benefit (p. 368). If a teacher cannot look past the potential problems, which may be minor, to see the potential benefit of a technology, he or she may dismiss it altogether without attempting to try the innovation. The students may miss out on valuable learning experiences. Vongkulluksn et al., (2018) found that beliefs about values were a stronger predictor of the quantity of technology integration than beliefs about teachers' own abilities and that "teachers with differing value beliefs place different 'relative weight' on access constraints" (p. 79). This means that teachers who place a high value on technology integration may place low value on access constraints because they are willing to work to find their own solutions.

Several studies exist regarding how teachers' attitudes towards technology affect their choices for how to integrate it into their classrooms. The research indicates that when teachers hold positive beliefs about how to effectively use technology in the classroom, they are more likely to integrate it into their lessons (Ertmer, Ottenbreit-

Leftwich, Sadik, Sendurur, & Sendurur, 2012; Kim, Kim, Lee, Spector, & DeMeester, 2013; Petko, 2012). While these studies are helpful in understanding the relationship between teachers' attitudes and their technology integration, the participants of these studies were mostly elementary school teachers. The integration of technology can vary widely from the elementary school level to the middle and high school levels (Varier et al., 2017). Elementary teachers use technology to provide students with access to content, whereas teachers at the middle and high school level use technology to provide opportunities for students to collaborate, communicate, and create, in addition to accessing content. This difference in how technology is used at different grade levels demonstrates a need for further research that focuses on secondary school teachers, specifically those who teach mathematics, as it will help guide teachers and leaders at the secondary level in making decisions about technology integration in the middle and high school grades.

This study will be helpful to the school district in making plans for professional development regarding technology integration. As the pilot study that used a similar population from the same school system discovered, middle and high school mathematics teachers in this district are not as confident in their knowledge of technology as they are in their knowledge of pedagogy or the content in their mathematics courses. This study may help leaders to identify areas of strength and weakness in teachers' attitudes towards technology and their own integration in the classroom.

Purpose of the Study

This study examined the technology integration of middle and high school mathematics teachers and their attitudes towards technology. The explanatory sequential mixed methods design was used (Creswell & Plano Clark, 2011). In this design, the quantitative data collected in the first phase of the study was used to select the participants for the second, qualitative data collection. A maximum variation sample was to be constructed for the qualitative data collection by identifying essential features and variable features of teachers' attitudes towards technology and used to provide what Patton describes as "high-quality, detailed descriptions of each case, which are useful for documenting uniqueness, and important shared patterns that cut across cases and derive their significance from having emerged out of heterogeneity" (as cited in Suri, 2011, p. 67). Key features of variations were to be identified, in this case, the overall mean scores and the mean scores of the nine constructs, and then cases were found that vary from each other as much as possible (Suri, 2011). Data collection was planned to begin by selecting three of the highest mean scores and three of the lowest mean scores and continuing to include one participant per group until no new or unique information was observed such that until saturation is reached (Green & Thorogood, 2004). However, after analyzing the results of the quantitative data, significant variations were not found so all eight of the volunteers for the qualitative phase were selected to participate. The focus of the study was on qualitatively examining the technology integration of middle and high school mathematics teachers from the participants' perspectives. It involved collecting quantitative data first to identify and purposefully select the most appropriate participants for the second phase, which is qualitative. The quantitative and qualitative data together were used to explore how the middle and high school mathematics teachers' use of technology in their classrooms reflect their attitudes towards technology. In the first, quantitative phase of the study, an online questionnaire, the Teachers' Attitudes

Toward Computers (TAC) Questionnaire, was used to collect data from middle and high school mathematics teachers in a small, rural school district in the Mid-Atlantic region of the United States to assess the attitudes of the teachers towards technology. The data from the first phase was intended to also be used to select participants for the second phase. In the second, qualitative phase, data regarding technology integration in mathematics classrooms was collected through interviews with teachers of varying attitudes. The qualitative data was analyzed using the RAT model (Hughes et al., 2006).

Research Questions

Three research questions guide this study. The main purpose was to understand if there is a relationship between secondary mathematics teachers' attitudes towards technology as indicated in the TAC questionnaire and how they use technology in their classrooms from the participants' perspectives. One of the two sub-questions was used to identify the attitudes of the teachers, while the other was used to identify how they use technology in the classroom. The main research question is:

- In what ways do secondary mathematics teachers' use of technology in the classroom reflect their attitudes towards technology?

The sub-questions that were used to answer the main research question are:

- What are the attitudes of secondary school mathematics teachers towards technology in the classroom as measured by the Teachers' Attitudes Toward Computers (TAC) Questionnaire?

- Based on teachers’ interviews, how is technology used in secondary school mathematics classrooms when viewed through the lens of the RAT framework?

Significance of the Study

The findings of this study contribute to the existing body of literature regarding teachers’ attitudes towards technology and their technology integration in the classroom. It helps fill the gap in the literature pertaining to middle and high school mathematics teachers. This study also adds to the research using the RAT model as the framework. Although this study focuses on one small school district, it may provide a foundation for further research regarding mathematics education and technology in other school systems. Expanding the research base can provide information that may be useful for improving mathematics education for many middle and high school students.

This study gave participants the opportunity to reflect on their own attitudes towards technology and how they integrate technology in the classroom. It provides information that may be useful to the stakeholders in the school system for improving mathematics education at the middle and high school level. The insights into the attitudes of the secondary mathematics teachers in the district and how technology is being integrated, provided by the study, may be helpful in the planning of professional development opportunities to improve the teachers’ attitudes, which may improve technology integration in mathematics classrooms.

Rationale for Methodology

A mixed method study with an explanatory sequential design is an appropriate design for the purpose of this study because both types of data were used to understand teachers' attitudes towards technology and how they use it in the classroom (Creswell & Plano Clark, 2011). The priority is placed on the second, qualitative phase rather than the first quantitative phase. The quantitative results are used to identify and purposefully select the best participants for the second phase (Creswell & Plano Clark, 2011) as well as to understand secondary mathematics teachers' attitudes towards technology in general.

First, the quantitative data were collected through the Teachers' Attitudes Toward Computers (TAC) Questionnaire (Christensen & Knezek, 2009), which assesses teachers' attitudes towards technology through Likert-scale items. The questionnaire was distributed to all secondary school mathematics teachers in the district, of which there are approximately fifty. The final item on the questionnaire provided participants with the opportunity to express interest in being interviewed about their technology integration. The data were analyzed such that the participants were grouped into relatively lower and higher scores with respect to their attitudes for the qualitative phase of the study (Creswell & Plano Clark, 2011).

Next, the quantitative data were to be used to select teachers to be interviewed about their technology integration. A maximum variation sampling was going to be used in order to identify the uniqueness of the two groups and shared patterns between the groups (Suri, 2011). However, the quantitative data did not show two distinct groups so the qualitative data was viewed as one whole group. The qualitative data from the face-to-face interviews were analyzed using the RAT model to determine the level of technology integration being used by the teachers. Finally, the qualitative results were used to explain the quantitative results (Creswell & Plano Clark, 2011).

The combination of the quantitative questionnaire and qualitative interviews provided insight into the general attitudes of the secondary mathematics teachers in the district as well as the specific technology integration methods, which were derived from the interviews. The interviewees were to be selected based on their demographic information (grade level, years of experience, and school) and mean scores on the questionnaire (lower and higher) to provide a varied sample but only eight were willing to participate in this phase and that quantitative data did not show two distinct groups. All eight were interviewed and the data from both phases were combined and analyzed as one whole group.

The quantitative data were collected through a convenience sample. The study was conducted in a small, rural public school district in the Mid-Atlantic Region of the United States. An email containing an invitation to participate and a link to the online questionnaire was sent to all the potential participants. In an effort to maximize the sample size, voluntary participation was requested during a professional development session on August 27, 2019, during which all the candidates are in attendance. It was emphasized that participation is voluntary and anonymous (unless they are willing to participate in the interview process) and that there is no penalty for opting out of participating.

Transparency of Insider Research

Due to the fact that the researcher is a high school math teacher in the school system being studied, it is important to address the concern of insider bias. Merton (1972) distinguishes between insiders and outsiders such that insiders share certain characteristics with the group being studied while outsiders do not. The researcher in this study is considered an insider, as a colleague of the participants.

Saidin and Yaacob (2016) found that when the researcher is an insider, there are advantages and disadvantages. One advantage is that the insider has a better understanding of the issues being studied. The researcher is a high school math teacher with over fifteen years of experience and training and education with regard to technology. This means that the researcher has a strong understanding of mathematics education and technology in the classroom.

Another advantage is that he or she holds a better rapport with the subjects of the study, which caused the subjects to be more open with the researcher (Saidin & Yaacob, 2016). The researcher has worked in the school system being studied for over fifteen years and has built a rapport with the majority of the potential participants. Many teachers in the district know the researcher through professional development with regard to mathematics education, teacher leadership, and technology integration.

Gaining consent by the necessary parties involved in the study, such as district and school administration and teachers, is another advantage of an insider in the role of the researcher (Saidin & Yaacob, 2016). The researcher has built relationships with and previously gained the consent of several of the aforementioned people for a prior study. This could make gaining consent a smooth process for this study.

A disadvantage is that the subjects tend to assume the researcher already knows what they know so they tend to not provide as much depth in their responses (Saidin & Yaacob, 2016). An insider as the researcher also introduces a potential bias that can invalidate the research. This potential issue was addressed through pre-structured questions that were asked of each interviewee. This eliminated the potential for asking leading questions. If the researcher suspected such assumptions are being made, the interviewee was asked to elaborate on an answer. The interview data for each interview was shared with the participant to ensure that the information is correct and true to the participant's intended answer.

Assumptions of the Study

It is assumed that all participants in both the first, quantitative phase and the second, qualitative phase answered honestly and openly to the best of their ability. The methods for maintaining anonymity and security of personal information were clearly explained to all participants prior to the administration of the questionnaire and the interviews to encourage genuine and truthful responses. All personally identifiable information was changed prior to any sharing of data with the school system or university. Interviews were conducted one-on-one in a location that is comfortable for the interviewee to encourage him or her to answer freely and honestly. Participants of the study were not impacted negatively or positively with regard to professional matters due to participation or lack thereof. Nor did they benefit financially or were penalized for lack of participation.

Chapter 1 Summary

This chapter describes the study while providing insight into its significance to the field of technology integration and teacher attitudes toward technology. It also describes the purpose of the study, defines the research questions, provides a description of the rationale for the methodology, and summarizes the researcher's conduct as an insider. The second chapter gives a detailed review of the literature regarding technology integration and teacher attitudes toward technology and the framework selected for this study. In the third chapter the methodology of the study can be found. The results of each phase of the study are described in chapter four with a discussion of the results answering the research questions included in chapter five.

CHAPTER TWO: REVIEW OF THE LITERATURE

Introduction

As the availability of technology in K-12 classrooms in the United States has increased in recent years, teachers and school systems are learning to use it to increase student achievement. Two factors that influence the integration of technology in the classroom are the teachers' knowledge of and attitudes towards technology (Graham, Borup, & Smith, 2012; Kim et al., 2013; Petko, 2012; Saudelli & Ciampa, 2016). The technological, pedagogical, and content knowledge (TPACK) framework was developed to assess teachers' knowledge in these three areas and the interrelationships of the types of knowledge (Mishra & Koehler, 2006). Two frameworks, RAT and Substitution-Augmentation-Modification-Replacement (SAMR), were created to assess technology integration in the classroom (Hughes et al., 2006; Puentedura, 2006). This study focuses on teachers' attitudes towards technology as they relate to technology integration in the classroom. The theoretical framework for assessing technology integration in this study is the RAT model. Each of the three aforementioned frameworks was reviewed to provide the rationale for the selection of the RAT model for the study.

Much of the existing literature regarding the attitudes towards technology in the classroom and its actual integration focuses on pre-service teachers (Gyamfi,` 2017; Horzum & Canan Gungoren, 2012; Lemon & Garvis, 2016; Li, 2005; Sadaf, Newby, & Ertmer, 2012; Teo, 2009; Yusop, 2015). Although these studies are important, they do not aid in the understanding of the relationships between the attitudes towards technology and the classroom integration of technology for practicing teachers as the subjects of these studies have not yet begun their careers. This study will add to the empirical research by examining a population of in-service middle and high school math teachers, a demographic that has been limited in previous studies.

Math teachers are using technology in their classrooms in a variety of ways and for a variety of purposes. Technology is used to change student-learning processes through the use of calculators (Homero Flores, Gomez, & Chavez, 2015), instructional methods such as the flipped classroom (Bretzmann, 2013; Palmer, 2015) and curriculum goals. While the RAT model was first published over 10 years ago, there are still few published research studies that have used the framework, even fewer that focus on the mathematics classroom. This study will add to the existing research by investigating the use of technology in middle and high school math classrooms using the RAT model as the framework for assessing how technology is being used.

Theoretical foundations/Conceptual framework

RAT Framework

The RAT framework expands on the work of Pea (1985) involving theories about technology in education and the research of Hughes (2000), which focused on teachers' use of technology in the classroom. The framework breaks technology use into three categories: (a) using technology as a replacement; (b) using technology as amplification; and (c) using technology as a transformation. It addresses the complexity of the teaching and learning process by using three themes; (a) instructional methods, (b) student learning processes, and (c) curriculum goals to guide the analysis of technology use (Hughes et al., 2006). Rather than a taxonomy of technology integration, the model provides a framework for viewing how technology is used in all aspects of teaching and learning and its appropriateness to the theme to which it applies. Table 2.1 provides a brief overview of the three categories and how the use of technology affects at least one of the three themes. The rows reflect the three themes within the classroom, including specific dimensions that may be addressed, in which technology can change a lesson or learning environment. The last three columns reflect each of the categories for the use of technology. The intersections provide a description of how technology is used for each category with an example.

Table 2.1 The RAT Model

Themes	Categories for Technology Use		
	Replacement	Amplification	Transformation
Instructional Methods 1. Teacher's role in instruction 2. Interaction with students 3. Assessment of students 4. Instructional preparation 5. Administrative tasks related to instruction (e.g. grading)	Technology is used to replace but not change any dimensions within the theme. Example: A teacher uses digital slides to deliver instruction to students while they take notes on the lesson. (This is an example of technology use as a replacement in an instructional method.)	Technology is used to improve efficiency, effectiveness, and productivity but no fundamental changes are made to any dimensions within the theme. Example: Students complete practice math problems on a digital program that provides immediate feedback to make learning more effective. Teacher can view students' progress making grading more efficient. (This is an example of technology use as an amplification in the student learning process.)	Technology fundamentally changes tasks in new and original ways for one or more dimensions within the theme. Ex: A teacher uses video lessons to provide direct instruction for students outside the school day. Students apply the concepts in class while the teacher acts as a facilitator more so than an instructor. (This is an example of technology use as a transformation in an instructional method and the student learning process because both themes are changed with the use of technology.)
Student Learning Processes 1. Learning activity/task 2. Thinking process - mental process 3. Knowledge transfer 4. Task milieu (individual, small group, whole-class, others) 5. Student motivation 6. Student attitudes			
Curriculum Goals 1. Curricular knowledge or concepts 2. Curricular experiences 3. Curricular processes or procedures			

Replacement

Using technology as replacement means that technology is replacing another tool. The instructional methods, student learning processes, and curriculum goals are not changed due to the use of technology (Hughes et al., 2006). For example, a student may graph a system of linear equations on a graphing calculator rather than using a pencil and a piece of grid paper. The calculator replaced the paper but there was no change to any of the three themes.

Amplification

Using technology as amplification involves using technology to amplify the instructional methods, student learning processes, and curriculum goals. The focus of using the technology is not on changing any of the three themes but on improving the learning by increasing efficiency or improving productivity (Hughes et al., 2006). An example of such practice is the use of a digital instructional tool that allows students in a math class to complete problems online rather than a hard copy textbook. Students submit assignments electronically and are provided with immediate feedback for each problem. This technology increases efficiency because the teacher does not spend extra time grading assignments. It improves productivity by providing feedback so students receive more practice based on their personal progress. However, there is no fundamental change to the instruction, learning process, or curriculum goals.

Transformation

When technology is used as transformation, it significantly changes at least one of the three themes. Technology can change the instructional methods by redefining the role of the teacher in the classroom. For example, when a Math teacher uses a flipped model in which students watch instructional videos for homework and apply concepts in the classroom, the teacher becomes a facilitator of learning rather than a lecturer (Bergmann & Sams, 2014). Student learning processes can change by providing students with new ways, which are inconceivable without technology, to learn the same content. For example, students can use the Internet to investigate applications for periodic functions and create a function to model a situation. Technology can transform curriculum goals by creating new goals due to the use of the available technology. An example of this is when a teacher creates new ways for students to compare graphs of functions using technological graphing tools.

The RAT framework was designed to view how technology is integrated in various aspects of teaching and learning (Hughes et al., 2006). It does not simply focus on what the students do or what the teacher does in the classroom but how technology affects the students' learning process, the instructional methods of the teacher, and the curriculum. By viewing technology use through each of these lenses, it broadens the scope of what technology integration is and looks like. It recognizes the many components of teaching and learning by considering the entire process.

This framework was used to evaluate the technology integration practices of the teachers in the study. Founded on research, the model provides a clear, organized process for categorizing technology integration practices. It will allow the understanding of how and why technology is selected by the teacher to be used by both teachers and students for instruction and learning. Similarities and differences in the technology integration of teachers with various attitudes towards technology were explored through the holistic view of how technology is being used in the middle and high school math classrooms provided by the RAT framework.

Additional Technology Integration Theoretical Frameworks

The integration of computer technology in K-12 classrooms has prompted the development of several frameworks. Three of the most prominent frameworks are TPACK, publicized by Koehler and Mishra (2009), SAMR, developed by Dr. Ruben Puentedura (Miyata, 2015), and RAT, described by Hughes, Thomas, and Scharber (2006). These frameworks have been used to guide and understand how technology is integrated in primary and secondary schools and classrooms (Koehler & Mishra, 2009; Hamilton, Rosenberg, and Akeaoglu, 2016; Hughes et al., 2006). There are other frameworks and models used in the field of educational technology, as well. In many cases, it is difficult to determine why and how one is chosen over another but it appears that “convenience and comfort on the part of the adoptees” plays a large role in the decision (Kimmons & Hall, 2016, p. 52).

TPACK Framework

The technological pedagogical content knowledge (TPACK) framework developed and published by Mishra and Koehler (2006) expands on the pedagogical content knowledge (PCK) framework of Shulman (1986). This framework was created through a series of theory-based design experiments focused on understanding teachers’ development toward using technology in the classroom. Through viewing the experiments collectively, the conceptual framework emerged. The framework provided a new way of viewing teachers’ knowledge of technology for informed decision-making (Mishra & Koehler, 2006). This framework provides an understanding of a teacher’s flexible knowledge in the three areas and how that knowledge is used to effectively teach with technology (Koehler, Mishra, & Cain, 2013).

According to Koehler et al. (2013), technological knowledge (TK) is the teacher's knowledge about informational technology for the purposes of communication, information processing, and problem solving. Cox and Graham (2009) mention that the definition is limited to emerging technologies to differentiate between TPACK and PCK. This definition allows for the adaptation of the knowledge as new technologies emerge in education.

Pedagogical knowledge (PK) is the teacher's knowledge about the methods, practices, and processes for teaching and learning. The pedagogical activities a teacher may use are categorized into general and content-specific strategies (Cox & Graham, 2009). Some strategies may be used in any or most classrooms regardless of content. These are the focus of PK.

Content knowledge (CK) is the teacher's knowledge about the subject matter to be taught and its topic-specific representations. According to Cox and Graham (2009), "this knowledge is independent of pedagogical activities or how one might use those representations to teach" (p. 63). Content knowledge is focused on the "what" of teaching and not the "how".

Technological pedagogical knowledge (TPK) is the teacher's knowledge about the methods, practices, and processes for teaching and learning with technology. It views the general pedagogical activities through the lens of emerging technologies (Cox & Graham, 2009). It does not involve content but can include classroom management strategies that use technology. The TPK will transform into PK as the technologies being used become universal and the emphasis on technology is no longer necessary. For example, books, at one time, were an emerging technology. They were not accessible to most people so the use of books in the teaching and learning process would demonstrate a teachers' TPK. However, books are now commonplace in the developed areas of the world and their use in the classroom has become representative of a teacher's PK.

Technological content knowledge (TCK) is the teacher's knowledge about technology that is specific to the subject matter to be taught. It refers to content representations that use emerging technologies (Cox & Graham, 2009). Similar to TPK, as the technologies become typical the TCK will become CK.

Pedagogical content knowledge (PCK) is the teacher's knowledge about pedagogy as it relates to the specific subject matter to be taught. As Cox and Graham (2009) mention, content-specific strategies may be further categorized into subject-specific and topic-specific. Subject-specific strategies may be used across various domains of a content area, while topic-specific strategies are used for topics within one domain. Topic-specific strategies are further grouped into activities, which is the pedagogy, and representations, which is the content.

Technological pedagogical and content knowledge (TPACK) is the teacher's knowledge about how all three components interact with one another. According to Cox and Graham (2009), TPACK refers to a teacher's knowledge of using emerging technologies to bring together topic-specific activities or subject-specific activities with topic-specific representations to facilitate student learning. Figure 2.1 shows a Venn diagram depicting the three core components of TPACK as circles and the sections that overlap to create new categories of knowledge.

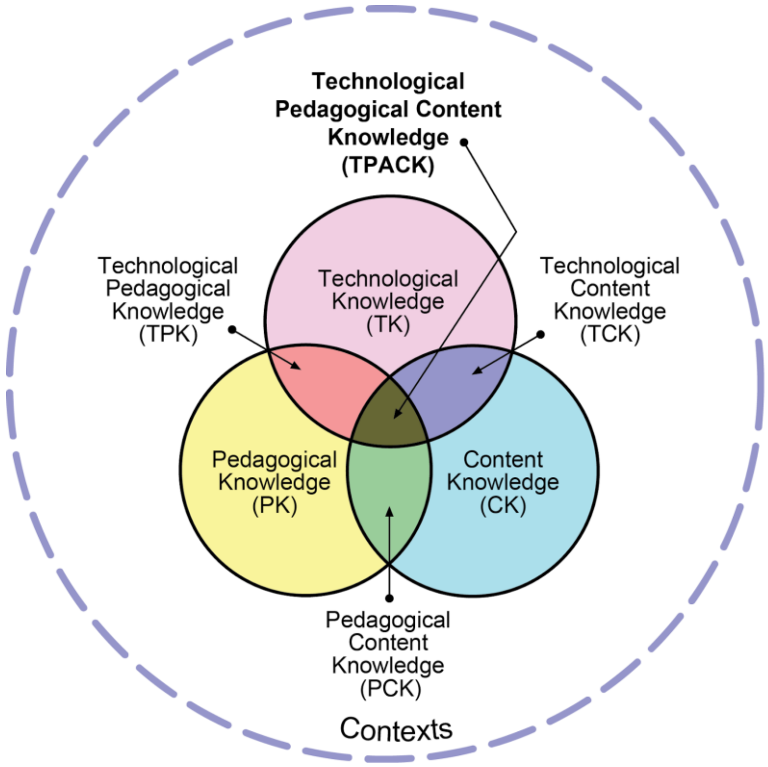

Figure 2.1 The TPACK Framework

TPACK was designed as a framework for teacher knowledge with regard to technology integration (Koehler & Mishra, 2009). Kelly identified the importance of context when using the TPACK framework (as cited by Rosenberg and Koehler, 2015). The context, which focuses on both the teacher and the student, includes micro factors, those in the classroom or learning environment, meso factors, those in the school or other settings in which the classroom or learning environment are found, and macro factors, those in society that affect teaching, learning, and the development of teachers and learners (Porras-Hernández & Salinas-Amescua, 2013). By viewing a teacher's TPACK in his or her context, the framework can be used to "examine how teachers' knowledge is constructed based on reflection on their practice" (Porras-Hernández & Salinas-Amescua, 2013, p. 235). It was designed to study the various knowledge of teachers and how it influences their practices. Interestingly, Cox (2008) found a connection between the levels of TCK and TPK and the grade level of the teacher. Her study implies that college professors have a stronger TCK, while elementary teachers have a stronger TPK and less TCK. This is an intriguing finding that warrants more research to support or refute the idea. While more solid research could be used in pre-service teacher programs and professional development programs for in-service teachers to improve knowledge in weaker areas, the focus of the current study is technology integration, not the knowledge that may influence it as it is for the TPACK framework.

SAMR Model

The SAMR model, developed by Dr. Ruben Puentedura, is a technology integration model that employs four hierarchical levels for technology use within a lesson (Puentedura, 2006). Teachers move through the levels as they integrate technology in their classrooms (Donahue, 2014). As shown in Figure 2.2, the first two levels, substitution and augmentation, are considered enhancements to the lesson. Technology is substituted for previously used tools with minimal or no functional improvements to the lesson. The last two levels, modification and redefinition, are considered transformations for the lesson. Technology is used to significantly redesign the lesson or create new tasks that would be impossible without the use of technology.

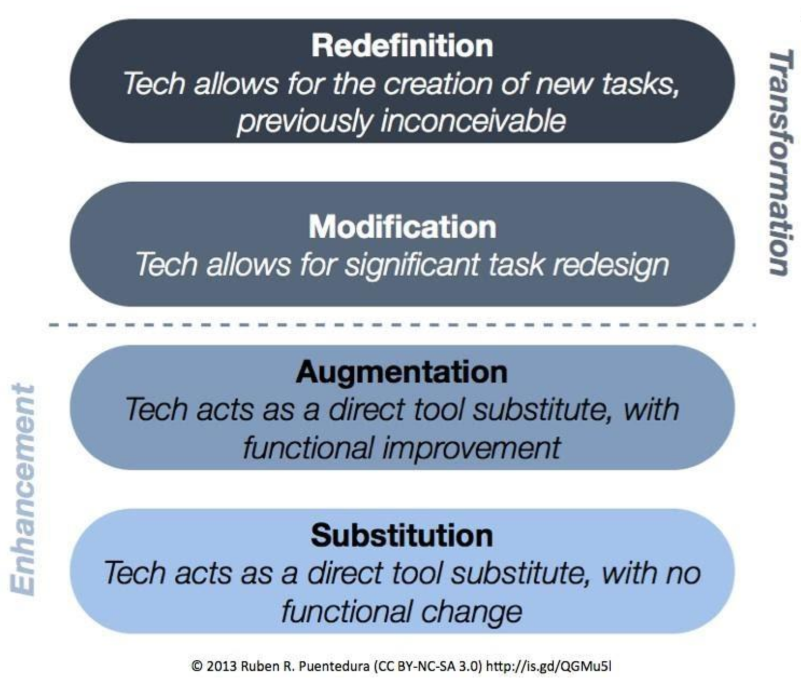

Figure 2.2 The SAMR Model

Substitution

Substitution is the lowest level of technology use in the classroom. At this level, a digital tool replaces an analog tool but there is "no functional change" (Puentedura, 2014) in the activities of the lesson. This is similar to the use of technology as a replacement in the RAT model. For example, students in a history course might type a research paper rather than write it using pen and paper. According to Donahue (2014), teachers at this level use teacher-centric instructional strategies and focus on content with little relationship to real-world application or skills.

Augmentation

The second level of technology use, augmentation, also uses technology as a direct substitution, however there is some functional improvement of the task (Puentedura, 2014). Students typing a research paper for history may use the spelling and grammar check features of a word processor to correct errors rather than a human editor.

Teachers at this level use technology to "control workflow" or manage classroom activities (Donahue, 2014, p. 30).

Modification

Teachers at the third level, modification, are significantly redesigning tasks (Puentedura, 2014). It is considered transformational because it changes the task in a way that is not possible without technology (Hilton, 2016). For example, students may use an online word processing program that allows classmates to collaborate and complete a research paper together. Each student can view and edit the document from his or her device while classmates are also viewing and editing the same document. The goal of the teacher, at this level, is to design lessons that incorporate 21st century skills, deepen learning experiences and seamlessly integrate technology (Donahue, 2014, p. 30).

Redefinition

Redefinition is the fourth and highest level. New tasks are created due to the use of technology. These tasks would be unimaginable without technology (Puentedura, 2014). Students may collaborate on a researching a topic for debate. Students must defend their argument through an audiovisual presentation using video tools. The task of a research paper has been redesigned in a way that changes the task and can only be accomplished with the use of technology. According to Donahue (2014), "all teaching and learning is student-centered" (p. 30). Teachers serve as facilitators and mentors and students are accountable for their own learning.

While this model has gained popularity with practitioners, there is a lack of peer-reviewed research in the development of the model (Linderuth, 2013; Hamilton et al., 2016). As a result, this model is open to interpretation and representation in different ways, which can lead to confusion about how it should be used and applied. In his open letter to Dr. Puentedura, Linderuth asked many questions about the foundation of the research. These questions included topics such as Dr. Puentedura's area of expertise, when and where the research took place, and who sponsored the research. A response from Dr. Puentedura regarding the open letter could not be found.

The hierarchical nature of the model leads to the misconception that teaching and learning with technology can and should be ranked using one of the four levels. Kirkland (2014) suggests that the model should not be used in this way but to use it to create richer learning experiences for students. While her recommendation is valid, the creator of the SAMR model (Puentendura, 2014) also designed the graphic most commonly associated with it, further encouraging its use as a taxonomy. Hamilton et al. (2016) discussed three challenges that demonstrate that this ranking may not be a valuable or necessary way to view technology integration.

Absence of Context

The SAMR model gives no attention to the context of the technology integration. The availability of resources, the learning needs of the students, and the teacher's knowledge of technology, pedagogy, and content are not considered in this model. This can lead to the over-generalization of how technology should be used while ignoring the aspects of the classroom that make it unique and complex (Hamilton et al., 2016). It may be presented as a one-size-fits-all solution to technology integration.

Rigid Structure

The SAMR model presents the levels of technology integration as four ordered categories or levels through which a teacher may progress. It assumes that technology is best used at the highest level, redefinition. As Hamilton et al. (2016) state, “this minimizes the more important focus on using technology in ways that emphasize shifting pedagogy or classroom practices to enhance teaching and learning” (p. 437). The model forces the dynamic learning process into a linear system with the goal of reaching the highest level.

Product over Process

The third challenge provided by Hamilton et al. (2016) is that the focus of the SAMR model is to change the product of a lesson rather than the learning process itself. Teaching and learning is a complex process that cannot be simplified to a set of products to demonstrate learning. The focus should not be on the technology tool that is being used but on the learning outcomes that are supported by the tool. Technology should enhance and support student learning, not be an educational goal itself.

Evaluating Models

Kimmons and Hall (2016) reviewed several frameworks and models, including TPACK, RAT, and SAMR, used in technology integration and provided six criteria by which models should be evaluated to try “to establish the value for one model over another” (p. 55). The criteria are “compatibility, scope, fruitfulness, role of technology, student outcomes, and, clarity” (p. 55). For each criteria, one model was provided as an example. For compatibility, the SAMR model was mentioned. This model is widely used by educators, most likely because it is compatible with current practices of teachers and acts as a guide through the four stages of technology integration. This is related to one of Rogers’ (2003) five qualities of an innovation that influences diffusion. The model has a high compatibility because it is easy to use. The TPACK framework was provided as an exemplar for fruitfulness. It has been used by a large number of researchers in various disciplines and encompasses the complex knowledge needed for effective teaching with technology. It provides a common way of viewing knowledge that allows for differences in disciplines. The problem with the use of TPACK in this way is that it is mentioned as a technology integration model, stating that these models are “essential for guiding thoughtful technology integration practices in existing educational contexts” (Kimmons & Hall, 2016, p. 51). However, TPACK was not designed to be a model for technology integration used to inform practices. It was designed to gather information about the kinds of knowledge teachers have and to inform professional development and growth opportunities for teachers (Koehler & Mishra, 2009). The RAT model was used to illustrate a high level of clarity. Using three distinct classifications, the model categorizes the impact of a technology on desired outcomes, as well as educational activities, which makes it less confusing and less likely to be misinterpreted (Kimmons & Hall, 2016). While the six criteria may be useful in selecting a technology integration model, Kimmons and Hall (2016) left the term “technology integration model” open to interpretation. Although technology may be a component of a model, it may not necessarily be the focus of the model, as is the case for TPACK. This article is helpful in noting a strength of each of the models and provides information to aid in selecting an appropriate model for a given situation.

Comparison of RAT and SAMR

The RAT model views the use of technology in the classroom through the three lenses of instructional methods, student learning processes, and curriculum goals (Hughes et al., 2006, p. 1617) whereas the SAMR model focuses on just the instructional activities with less consideration of the learning process (Hamilton et al., 2016). As Hughes et al. (2006) mention, "simply identifying the technological applications in use does not help the field think about the role(s) of technology in education (p. 1616). The SAMR model is appealing to teachers by providing a model that is "easy to apply as a reflective lens" (Hilton, 2015, p. 72) but it has such a strong focus on the technology being used that it misses the whole picture of all the components of student learning. For example, Mueller and Oppenheimer (2014) conducted a study of students' note-taking practices using digital tools or longhand, which was referenced by Puentendura (2014) as a good example of substitution using his model (as cited by Hamilton et al., 2016, p. 436). However, the research of Mueller and Oppenheimer (2014) supports the use of longhand note-taking over digital methods through higher performance levels. Substituting digital note taking for written note taking did not have a positive impact in this study. The study showed that the process of writing helped students with conceptual understanding. This example shows why the idea of product over process is not always better. By focusing on the product of digital notes, the process involved in the use of handwriting and its relationship to learning was overlooked. While technology can be a great tool for enhancing lessons, it does not always improve learning and its potential benefits and disadvantages must be carefully considered. The SAMR model implies that technology inherently improves learning.

While the SAMR model is task-oriented and focuses on what a student produces, the RAT model is process oriented and focuses on what the teacher and students are doing during the lesson and how technology is supporting and enhancing learning. "The RAT framework provides teachers with a tool to assess the extent to which their use of a practice…supports teaching for understanding” (Stockero et al., 2011, p.708). Technology can be used to improve many aspects in the classroom. The RAT model provides a way to evaluate all the many ways it is used to inform decisions methods, activities, and processes. It is a holistic approach to assessing technology in the classroom.

Although the SAMR model attempts to distinguish the hierarchical levels, dividing them into categories of enhancement and transformation, the difference between level 2, augmentation, and level 3, modification, is ambiguous. The RAT model uses just three levels that are more clearly defined and not hierarchical. The goal of this model is not to reach the highest level, as it seems with the SAMR model, but to assess technology use and guide teachers in making instructional decisions about technology integration adoption (Hughes et al., 2006).

Influence of TPACK

The purpose of TPACK is to inform planning so that educational technologies can be effectively integrated into instruction. Teachers must account for the curriculum requirements, available technologies, student learning needs, and the context of the learning environment (Harris & Hofer, 2011). Since TPACK is based on emerging technologies, the application of the framework must adjust as technologies become the norm and are no longer considered emerging (Cox & Graham, 2009). Where the SAMR and RAT models are used to evaluate the use of technology in the learning environment, the TPACK framework was designed for instructional planning. Although, it may be promoted by some as a technology integration model, it was developed as a “construct for measuring a teacher’s knowledge and capacity to integrate technology in instruction”

(Green, 2014, p. 41). Therefore, it should not be used to assess or prescribe the use of technology. Rather, it should be used to plan professional development for teachers to promote growth in knowledge and capacity and to plan effective instruction that maximizes teacher strengths and student learning opportunities.

Comparison of RAT and TPACK

The constructs of TPACK (technological, pedagogical, and content knowledge) align, in several ways to the themes of the RAT model (instructional methods, student learning processes, and curriculum goals). The application of the themes in the RAT model is influenced by the PCK of the teacher. The category of technology used in the RAT model is influenced by the TPK and the TCK of the teacher. The TPACK of teachers can be measured to design professional learning experiences based on the need for growth, while the RAT model could be used to evaluate the use of technology and measure the effectiveness of the experiences by measuring the change in how technology is used within the classroom. As teachers' TPACK increases, the use of the RAT model should reflect the change in the classroom by showing an increase in the effectiveness of technology use.

It is also worth noting that Mishra et al. (2016), one of whom helped develop TPACK, selected the RAT model for their research recognizing that "while this three-fold categorization provides us with ways of thinking about how e-leadership can unfold, it is never a deterministic or predictive model" (p. 255). The results of the integration of a technology depend on the factors of the system, which are unique to the school and in constant fluctuation. This further supports the use of the RAT model as the method for understanding, rather than prescribing, how technology is integrated in order to inform decisions. When used together, TPACK and RAT can provide valuable information for educators and administrators to use for improving student learning through technology integration.

RAT Model in Research

The RAT model has been used as a framework to explore the integration of technology into classrooms. In a study that explores the relationship between Taiwanese high school teachers' conceptions of mobile learning and the RAT framework, Hsieh and Tsai (2017) found that one conception, meeting student preferences, translated to replacement because the means changed while the end remained the same. Two conceptions, conducting classes efficiently and invigorating/enhancing learning, were placed in amplification because efficiency and productivity were increased. The last three conceptions, parting from tradition, focusing on student ownership, and extending learning, were using technology as transformation by reshaping the content, instructional methods, and student learning processes (Hsieh & Tsai, 2017, p. 93). Blanchard, LePrevost, Tolin, and Gutierrez, (2016) conducted a study that examined if teachers who engaged in technology-enhanced professional development (TPD) change their beliefs about teaching and their practices. They used the RAT framework to assess the changes in teacher instruction as it related to technology. It was found that the most prevalent category was amplification with replacement as the least prevalent. Regarding amplification, this is consistent with the findings of Hughes et al., (2017).

This model has also been used to evaluate other tools in addition to educational technology integration. Mishra, Henriksen, Boltz, and Richardson (2016) applied the RAT model to a study of e-leadership. They matched Gurr's (2004) three categories of e-leadership: “More of the Same,” “Leadership Plus,” and “A New Type of Leadership” (p. 116-119) with the three categories of RAT, replacement, amplification, and transformation, respectively. They examined the way technology is used in leadership and teacher development and found that technology is used in a variety of ways for these purposes. In order for transformation of organizations and leadership to occur, knowledge needs to be developed, specifically that of skills, capabilities, “networks and social relationships between people” (p. 262).

While the RAT model was originally designed to be applied to educational technology, in their study, Stockero et al. (2011) used it to examine a teaching tool that did not necessarily use technology. Although, with some modification, it could. They found the model useful for planning to use a new teaching tool or improving the current use of a tool. They studied the use of student solutions and explanations as a teaching tool and categorized the methods using the RAT framework. Replacement was found when students simply showed their work for a problem on the board. Amplification included the work and a verbal explanation of the work. Transformation happened when the work was displayed, a verbal explanation was given, and a discussion about the underlying mathematical concepts ensued with questions that connected the concepts to other ideas. The use of the RAT model demonstrates its value as a framework for improving student learning, not only with a focus on technology but also with any teaching tool.

Training teachers on how to use technology in the classroom can aid teachers in integrating technology at new levels. Bozkurt et al. (2014) studied five classroom and five primary mathematics teachers before and after professional development that focused on technology integration in the mathematics classroom. They found that, before training, teachers either used no technology or at the replacement level, while, after training, five teachers used it at the amplification level and two used it at the transformational level.

When the RAT model was used in mathematics classrooms to evaluate technology integration, it was found that amplification was the most frequent category of technology use in the classroom. Hughes et al. (2017) used the RAT model to assess the ways in which two mathematics and two science teachers integrate iPads for STEM teaching and learning. They found that the technology was most used as amplification and least used as transformation. In their study comparing three high school mathematics teachers' technology integration before and after in-service on a mathematics-specific software, Ardic and Isleyen (2017) found that before the in-service, the teachers were either not integrating technology in the classroom or were doing so at the replacement level, while after the in-service, the teachers were observed to be integrating technology at the amplification and transformation levels.

The RAT framework provides teachers with a tool to assess the use of a new teaching tool and to improve the use of an existing tool already in use (Stockero, Van Zoest et al., 2011). Stockero et al. (2011) used the framework to assess the various uses of a teaching tool to guide students' development of mathematical understanding. "The existence, versatility, and power of technology make it possible and necessary to reexamine what mathematics students should learn as well as how they can best learn it" (NCTM, 2014, p. 3). When teachers hold attitudes that the intentional use of technology can improve mathematical understanding, the impact of their technology integration will increase.

Use of Technology in the Classroom

The implementation of 1:1 devices in the classroom has been more challenging and complex in secondary schools than in primary (McFarlane, Triggs & Yee, 2009; Ng & Nicholas, 2009). However, as secondary teachers increase technology integration in their classrooms and move across the continuum from replacement to transformation, students are reaping the benefits of high achievement, particularly in math and science (Killion, 2016).

Using the RAT framework, we can describe how teachers are using technology to intensify student learning processes, instructional methods and curriculum goals. Technology could enhance the student learning process by helping students with organization and fostering student engagement through visual stimulus, gamification, and interactivity. It allows for information to be found more quickly and easy manipulation of content and complex models. It offers experiences for students that may be otherwise impossible (Bertram & Waldrip, 2013). Technology could change instructional methods by fostering less teacher-centered and more student-centered learning environments (Ramírez, Clemente, Cañedo, & Martín, 2012). It enables teachers to be innovative and try new methods including online networking and collaboration among students across the schools. This has the potential to foster a sense of community among students who may not normally have the opportunity to interact (Bertram & Waldrip, 2013). The curriculum goals could be changed through technology by changing the knowledge to be gained or experience to be applied. Technology can change the experience by providing an inquiry-based learning environment for students (Karam et al., 2017).

Use of Technology in the Mathematics Classroom

Technology is used in a variety of ways in the math classroom. Teachers incorporate the use of calculators to reduce the amount of time spent on "complex and boring calculations" and allow students to "solve more complicated problems and focus on the solving process itself and the mathematics behind the problem" (Homero et al., 2015, p. 80). The flipped classroom is a teaching model in which educators use video lessons assigned for homework to replace direct instruction in the classroom. Class time gives students time to apply their knowledge in problem-solving situations. Math teachers are using technology to create, assign, and deliver the videos in an effort to maximize the direct contact with students (Bretzmann, 2013; Palmer, 2015). Blended learning has also been shown to be an effective method for teaching mathematics with technology. In one study using this model, teachers spent approximately 60% of in-school instructional time in facilitating classroom activities and 40% facilitating the use of computer-based, individualized instruction provided by math educational software and found that students had better outcomes on assessments than those whose teachers used more traditional methods of instruction (Karam et al., 2017).

To impact students' learning, teachers must have positive attitudes towards technology and learn how to use it effectively in their classrooms. Norton, McRobbie, and Cooper (2000) studied the relationship between math teachers' attitudes and their use of technology in the classroom. They found that those who had a teacher-centered pedagogical style used technology for computational and other low level activities, while those with a learner-centered style used technology to "construct mathematical meaning and explore the fallible nature of mathematics" (p. 105).

Teachers’ Attitudes towards Technology

Teachers are comfortable with technology and want to use it in their classrooms. Ertmer (2012) stated that 85% of teachers in the United States report feeling “somewhat well-prepared” to use technology for classroom instruction and over 80% have a desire to learn how to integrate technology into their classrooms. Many teachers are enthusiastic and optimistic about technology, believing that the more knowledge they have of technology, the more likely they are to use it in their classrooms (Yu, 2012).

While teachers believe that technology can have positive benefits for their students, in order to feel comfortable with specific technologies, teachers need to spend time with the technology themselves before trying to integrate them into the classroom (Constantine, Różowa, Szostkowski, Ellis, & Roehrig, 2017). Chiu and Churchill (2016) used questionnaires to collect data from secondary school teachers about their beliefs, attitudes, and anxiety towards using mobile devices in the classroom before adoption and ten months after adoption. Before the mobile device adoption, teachers received professional development on how to use the devices in their classrooms. They found that the adoption of mobile devices did not improve teachers’ attitudes towards teaching with mobile devices but did improve the levels of anxiety. Math and science teachers’ scores on their questionnaires showed significant improvement regarding computer self-efficacy, perceived usefulness, and perceived ease of use because the technology could help them achieve their teaching goals. Additionally, this improvement was “significantly larger than that of the language and humanities group” that did not believe the devices were appropriate teaching and learning tools for their teaching goals (p. 321). Ng and Nicholas (2009) used interviews and observations to study how teachers integrate the use of pocket PCs in their classrooms, as well as the change in attitudes of the teachers about the technology. The secondary teachers in the study demonstrated a feeling of uncertainty regarding the technology due to a lack of technical support and colleagues interested in collaborating. However, they believed it is a "motivating tool that could engage students, promote good behavior, and encourage both independent learning and teamwork" (p. 478). Although pocket PCs were used in primary math classes and secondary English and science classes, Ng and Nicholas (2009) found no reports of use in the secondary math classes.

Mathematics Teachers' Attitudes towards Technology

The limited studies of mathematics teachers' attitudes towards technology show that professional development on technology integration in the math classroom improves teachers' knowledge, skills, and attitudes towards technology. After a four-week institute providing professional development on technology, Hartsell, Herron, Fang, and Rathod (2010) found that teachers were more confident in their knowledge and abilities to integrate technology into their middle school math classrooms. They also had more positive attitudes towards technology integration.

A study comparing the attitudes of two distinct groups of middle and high school math teachers about graphing calculators and software found that professional development that spans a longer time frame and is held more frequently is more effective in improving teachers' attitudes towards technology than just a few sessions (Gningue, 2003). One group took a fifteen week, 45-hour graduate course that focused on these technologies while the other group participated in a series of three workshops totaling seven hours with the same focus. Teachers who took the course reported a significant difference in their attitudes towards the use of technology in the math classroom before and after the course, while those in the workshop reported an improvement that was not statistically significant. The long-term training had a greater impact on the teachers' attitudes towards technology than the short-term training.

Li (2003) found that mathematics teachers believe that instructional technology can be an effective learning tool in the math classroom but is only a tool and should be used properly.

Effect of Attitudes on Use of Technology

Teachers' attitudes towards technology affect their choices for how to integrate it into their classrooms. Petko (2012) found a significant positive correlation between teachers' beliefs about the effectiveness of technology and its use in the classroom. He determined that teachers are more likely to use technology in the classroom when they believe that it will improve students' learning. Kim et al. (2013) found that "what teachers say they do was significantly correlated with both their beliefs about effective ways of teaching and their actual practices with regard to technology integration" (p. 81). In a study of 12 award-winning technology-using teachers, Ertmer et al. (2012) found that 11 of the 12 held beliefs about best practices using technology that aligned with their actual use of technology in the classroom. The research indicates that when teachers hold positive beliefs about how to effectively use technology in the classroom, they are more likely to integrate it into their lessons.

Using the Teachers' Attitudes towards Computers (TAC) Questionnaire, found in Appendix A, Challoo, Green, and Maxwell (2010) found that the level of technology integration is influenced by the attitudinal constructs with the most significant being the teachers' comfort levels with computers.

Chapter Two Summary

Teachers are using technology in the classroom to improve student learning processes, instructional methods, and curriculum goals (Bertram & Waldrip, 2013; Karam et al., 2017; Ramírez et al., 2012). Of the three frameworks that focus on technology integration, the RAT model best fits this study because it is used to assess the levels of technology integration in the classroom in a holistic way through the three aforementioned categories (Hughes et al., 2006). This study will use the RAT model as the framework for evaluating technology integration an effective tool for assessing how technology is used to meet the goals of the learning (Stockero et al., 2011).

Most teachers are comfortable with technology and believe that as their knowledge of technology and how to use it increases, the likelihood that they will integrate it into their classroom will also increase (Ertmer, 2012; Yu, 2012). Teachers who have positive attitudes towards technology actually integrate it into their classrooms in effective ways (Ertmer et al., 2012; Kim et al., 2013; Petko, 2012). This study will also add to the existing literature regarding the attitudes towards technology in the classroom and its actual integration, much of which focuses on pre-service teachers, not in-service teachers (Gyamfi, 2017; Horzum & Canan Gungoren, 2012; Lemon & Garvis, 2016; Li, 2005; Sadaf et al., 2012; Teo, 2009; Yusop, 2015).

Mathematics teachers use technology in a variety of ways. Calculators are used to make mundane calculations more efficient allowing for more time to be spend on problem solving processes (Homero et al., 2015). Videos are used to provide direct instruction to maximize class time with students (Bretzmann, 2013; Palmer, 2015). Blended learning environments provide a mixture of classroom learning activities that do not utilize technology with those that do. Many mathematics technology tools provide individualized instruction. This blended learning environment can provide students with better outcomes, such as higher scores on assessments, than those whose teachers used more traditional methods of instruction (Karam et al., 2017). Studies show that technology use in the mathematics classroom is categorized most frequently as amplification rather than replacement or transformation (Hughes et al., 2017; Bozkurt et al., 2014). This study will add to the existing literature regarding what technology is used in the mathematics classroom and how it is being used with the RAT framework as the tool for evaluation.

CHAPTER THREE: METHODOLOGY

Introduction

There is a need for more research regarding teachers' attitudes towards technology and how they integrate it into their classrooms. The constantly changing nature of technology creates challenges for school systems as they work to increase the availability and use of technology. There are barriers that hinder the integration of technology in the classroom, such as the teachers' negative attitudes towards technology (Vongkulluksn et al., 2018). Understanding the relationship between these two concepts can help administrators and teachers address the issue and work toward positive change.

The focus of this mixed methods study was to examine the attitudes of secondary mathematics teachers towards technology and their technology integration. The quantitative data involving the teachers' attitudes was collected first and the participants volunteered for the second phase, which is qualitative and explores the teachers' technology integration in their classrooms. This chapter further discuss the design and methodology of the study, as well as describes the participants and the context of the study. It elaborates on the instruments used for data collection and the methods for analysis of the data. Finally, it addresses ethical considerations for the study and the limitations involved.

Statement of the Problem

Access to technology in the classroom is steadily increasing. With the increase in access, there should be an increase in use. Otherwise, is it worth the expense? Teachers' attitudes toward and perceptions of the integration of technology into their classrooms are a major contributor towards the success or failure of technology integration initiatives (Tomlinson, 2015). It is important to understand the relationship between teachers' attitudes toward technology and how they use it in the classroom in order to make decisions that will lead to the success of these initiatives.

This study examined how middle and high school mathematics teachers' technology integration reflects their attitudes towards technology. Quantitative data from a questionnaire was used to evaluate the teachers' attitudes, while qualitative data from interviews was used to evaluate their technology integration. The RAT model was used as the framework through which the qualitative data was analyzed. This study attempts to fill the gap of research linking middle and high school mathematics teachers' attitudes and their technology integration.

Research Questions

The main focus of this study was to examine the technology integration of middle and high school mathematics teachers and their attitudes towards the use of technology. This was addressed through two subcategories. The first is to identify the attitudes of the teachers. The second is to identify how they use technology in the classroom. A mixed methods approach was selected because a quantitative representation of the teachers' attitudes followed by qualitative interviews about their technology integration will allow a deeper understanding of how their attitudes are reflected by their descriptions of technology integration in their classrooms (see Figure 3). The Teachers' Attitudes Toward Computers (TAC) Questionnaire was used to collect quantitative data, allowing for the first research question to be answered quickly and efficiently, while providing a descriptive picture of teachers' attitudes towards technology. The first sub-question is:

- What are the attitudes of secondary school mathematics teachers towards technology in the classroom as measured by the Teachers' Attitudes Toward Computers (TAC) Questionnaire?

Qualitative research best serves the purpose of understanding how teachers integrate technology into the classroom because it allows for an in-depth view of technology integration behaviors from the participants' perspectives. Therefore, the second phase of the study included interviews with participants based on their TAC scores to answer the second question. Voluntary participants were interviewed to provide an inclusive picture of technology integration in mathematics classrooms across the district. This sampling method revealed the uniqueness of each case, as well as any shared patterns across the group (Suri, 2011). The second sub-question is:

- Based on teachers' interviews, how is technology used in secondary school mathematics classrooms when viewed through the lens of the RAT framework?

The final phase of the study merged the results of the first two phases by analyzing the qualitative data considering the TAC scores. By doing so, teachers' attitudes were considered on how they use technology in the classroom. For example, how do teachers' TAC scores in certain constructs relate to their use of technology in the classroom? Thus, the main research question, which connects the two methods, is:

- In what ways do secondary mathematics teachers' use of technology in the classroom reflect their attitudes towards technology?

Research Design and Methodology

This study follows a mixed method design because both types of data were used to understand how secondary school mathematics teachers' use technology in the classroom reflect their attitudes towards technology. The quantitative data were used to identify the teachers' attitudes, while the qualitative data were used to understand how the teachers are integrating technology into their classrooms. Then, both types of data were used to understand how teachers' technology integration reflects their attitudes towards technology. As described by Creswell and Plano Clark (2011), the explanatory sequential design was intended to be used to collect a maximum variation sample. The explanatory sequential design, as shown in Figure 3.1, was used because the study begins with the collection of quantitative data and follows up on specific results with the second, qualitative phase. It involved collecting quantitative data first that would help to purposefully identify the participants for the second phase. A maximum variation sample was to be constructed for the qualitative data collection by identifying the mean scores for each teacher's attitudes towards technology and selecting participants with the highest mean scores and participants with the lowest mean scores. However, after reviewing the mean scores for each participant, it was determined that the variation in the scores was too small to create two distinct groups. Interview data provided detailed information in the qualitative phase about the uniqueness of each case, as well as any shared patterns across the group (Suri, 2011). The participant-selection variant was the best design for this study because the focus of the study was on qualitatively examining the technology integration, which was the second phase, rather than the quantitative data from the first phase.

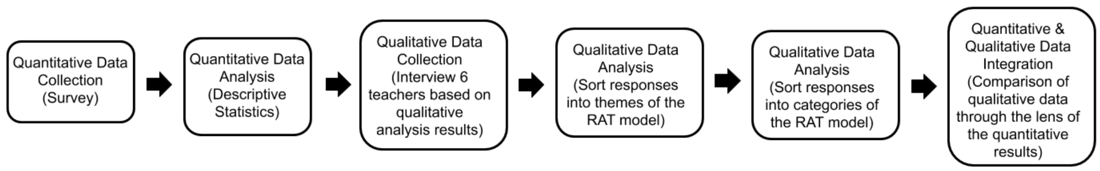

Figure 3.1 Explanatory Sequential Mixed Methods Design Figure

In the first, quantitative phase of the study, an online questionnaire, Teachers' Attitudes Toward Computers (TAC) Questionnaire by Christensen and Knezek (2009), found in Appendix A, was used to collect data from middle and high school mathematics teachers in a small, rural school district in the Mid-Atlantic region of the United States to assess the attitudes of the teachers towards technology. The questionnaire was distributed to all middle and high school mathematics teachers in the district, of which there were approximately fifty. The questionnaire had two demographic items and 52 Likert-scale items to gather information about the teachers' attitudes towards technology. The Likert-scale items were categorized by nine factors regarding technology: interest, comfort, accommodation, interaction, concern, utility, perception, absorption, and significance. The final item on the questionnaire provided participants with the opportunity to express interest in being interviewed about how they integrate technology in their classrooms. The data was analyzed with the intention that the participants would be grouped into relatively lower and higher scores with respect to their attitudes for the qualitative phase of the study (Creswell & Plano Clark, 2011). However, the quantitative analysis did not provide two distinct groups so the data from the qualitative phase was analyzed as one group.

In the original research design, the quantitative data were going to be used to select teachers with the lowest mean scores on the TAC and teachers with the highest mean scores on the TAC who agreed to be interviewed and provided their contact information on the questionnaire. Demographic information (grade level and years of experience) and scores on the questionnaire (lower and higher) was going to be used to provide a varied sample and participants from the phase 1 sample were going to be invited for interviews until thematic saturation was reached, which would start with three participants per group (low and high) and continue to include one participant per group until no new, unique information were observed (Green & Thorogood, 2004). As previously mentioned, the quantitative results did not indicate two distinct groups so the original design was modified to one group for the qualitative phase. In addition a total of eight participants provided their contact information to participate in the qualitative phase so all eight were interviewed. This sample size is within the size parameters of 3 to 15 individuals, as recommended by Creswell (2013). The selected teachers were interviewed about their technology integration using the questions found in Appendix B.

As participants responded to the questions, the researcher asked for clarification or expansion on answers. The qualitative data from the face-to-face interviews were analyzed using the RAT model to determine the level of technology integration being used by the teachers. Finally, the qualitative results were used to explain and expand upon the quantitative results (Creswell & Plano Clark, 2011). The combination of the quantitative questionnaire responses and the qualitative interviews provided insight into the specific technology integration methods for teachers with different attitudes towards technology.

Context

The school system being studied, which adopted the Common Core State Standards (CCSS) as the foundation for its math curriculum, began the implementation of a 1:1 digital conversion in the 2015-2016 school year. The goal of the program was to provide a digital device for each student in the school system. The type of device and use varied by grade level. Students in Pre-kindergarten through second grade use iPads, while students in third through eighth grades use Chromebooks. High school students, ninth through twelfth grade, use laptops. All ninth-grade students in the district received a laptop. Each year thereafter, the incoming freshmen received a laptop such that by the 2018-2019 school year, every high school student had a laptop to use at school and at home during the school year. Each high school also received mobile hotspots to lend to students who did not have access to the internet at home so they could complete assignments for school.

During the first year of implementation, the middle schools in the district began purchasing carts of Chromebooks for students to use in the classrooms. The Chromebooks are kept in the school and are not taken home by students. Each year more carts were purchased. By the 2018-2019 school year, the student to Chromebook ratio was approaching 1:1.

With the implementation of devices in the classroom beginning in 2015, online resources were purchased to support the initiative and the mathematics curriculum. Engrade was the online resource delivery system used by the district. Teachers had access to provide instructions, assignments, assessments, and links to resources for students on the platform. For both middle and high school, the Discovery Education Techbook was adopted as the primary resource to provide lessons, activities, performance tasks, and practice exercises for 7th and 8th grade, Algebra 1, Geometry, and Algebra 2. Other online programs such as MyLabsPlus ™ and WebAssign were used as supplements to the textbook for specific high school math courses. These programs provided practice exercises and assessments. In addition to these primary resources, supplemental digital resources such as Desmos™, Geogebra™, and Geometer's Sketchpad™ were used as tools for graphing and modeling mathematics. In the fall of 2018, Illustrative Mathematics™ curriculum resources were implemented in the 7th and 8th-grade math classes. This open education resource provides a full course curriculum that may be used in place of the Discovery Education Techbook™. During the spring of 2019, several high school mathematics teachers across the district piloted two units of the Illustrative Mathematics™ curriculum for Algebra 1, Geometry, and Algebra 2. In addition, approximately 10% of teachers across the district also piloted Schoology™, the learning management system that was fully implemented in the district beginning in the fall of 2019.

Participants

Approximately fifty mathematics teachers of grades 6-12 in a small, rural public school system in the Mid-Atlantic region of the United States in the fall of 2019 were invited to participate in the study. The school system has three comprehensive high schools, one technical high school, three middle schools, and one intermediate school. One comprehensive high school has over 1,300 students, while the other two have approximately 350 students each. The technical high school services students from the three comprehensive high schools such that students attend this school for part of their day. This school has one teacher who teaches mathematics courses. One middle school serves over 650 students in grades 7 and 8, while the other two serve approximately 375 students in grades 4 - 8. In each of these two middle schools, about 225 of the students are in grades 6, 7, and 8. The intermediate school serves about 800 students in grades 4 - 8, approximately 350 of whom are in 6th grade. Each school has various access to technology. The two smaller high schools were renovated in the past 10 years and have newer technology, such as SMART boards, in each classroom. While the largest high school is continuing to improve technology, not all classrooms are equipped with interactive whiteboards such as SMART boards. Technology in classrooms is more consistent across the middle schools and intermediate school as each school has updated rooms as funding allows. Some classrooms have interactive whiteboards, while others do not. In all of the schools except the largest high school, teachers have their own classrooms. There are about 5 mathematics teachers in the biggest high school who travel to various rooms throughout the school day.

Once twenty-eight teachers (over 50% of the population) had responded to the questionnaire, the data were analyzed and it was determined that all eight participants who were willing to participate in the qualitative phase would be interviewed. Literature suggests about 53% as a common response rate for surveys used in organizational research (Baruch & Holtom, 2008). A sample size of at least 25 was selected to accommodate the time constraints of the study. However, efforts were made to obtain a sample of 30. In a previous study involving teachers in this district, the survey response rate was approximately 50%. The invitation to that study and the link to survey was sent through email during the second week of September with two additional reminder emails in order to obtain the 50% response rate. The initial invitation and link to the survey in this study was sent to teachers during a professional development session in August with the goal of having teachers who would like to participate completing the survey that day. By inviting the teachers in a face-to-face environment, the response rate was expected to be higher than only sending the invitation through an email (Nulty, 2008). Ideally, the selected participants would reflect the diversity of all respondents with regard to attitudes towards computers as well as other demographic data.

Instrumentation and Sources of Data

For this study, both quantitative and qualitative data were collected. The Teachers' Attitudes Toward Computers (TAC) Questionnaire version 6 (Christensen & Knezek, 2009) was used to gather quantitative data. The TAC was selected as the quantitative data collection instrument because it was shown to have a high reliability and validity across teachers of different grade levels and demographics. It was developed from "selected sets of items from 14 well-validated computer attitude survey instruments" (Christensen & Knezek, 2009, p. 143). The questionnaire has been refined several times such that the latest rendition, version 6, contains 52 Likert-type items within nine constructs: interest, comfort, accommodation, interaction, concern, utility, perception, absorption, and significance. Christensen and Knezek obtained data from 2003, 2006, and 2008 using the TAC version 6 and found that the coefficient alpha for each of the constructs fell between 0.87 and 0.95 for all three sets. This questionnaire has been used to examine the effects of four of the attitudinal constructs from the TAC on the stage of adoption of technology using a path model (Chaloo et al., 2010). Green (2015) used the questionnaire in a study that explored the relationship between K-12 teachers' technology skill level, self-efficacy, and attitude toward integrating technology in their classrooms. He performed a correlation analysis to determine the relationship between various responses on the TAC questionnaire and another questionnaire, the Technology Integration Matrix.

In addition to the 52 Likert-scale items in the TAC that were used to gather information about the teachers' attitudes towards technology, the questionnaire has two demographic items, years of experience and grade level. The final item on the questionnaire provided participants with the opportunity to express interest in being interviewed about their technology integration. The questionnaire was hosted on Qualtrics, an online surveying tool, which is password-protected. Data from Qualtrics were transferred to a spreadsheet for analysis, which was stored in a secure, password-protected drive provided by the institution.

A link to the questionnaire was emailed to the fifty teachers to be completed voluntarily. It included the opportunity to provide the name of the participant if he or she was willing to be interviewed. Since less than twenty-five teachers participated, the questionnaire was sent a second and third time to collect more data. The quantitative data collected from the questionnaire were used to address the first research question regarding teachers' attitudes towards technology (see Table 3.1). The responses for levels of agreement were coded numerically such that 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree.

Then descriptive statistics, including frequency, mean, median, mode, and standard deviation, were calculated to analyze the attitudes of the teachers towards technology. Since the individual responses on the questionnaire were not indicative of two distinct groups, all eight volunteers were selected to participate in the qualitative phase.

Table 3.1 Alignment of Research Questions to Data Analysis

Research Question	Data	Data Analysis
What are the attitudes of middle and high school mathematics teachers towards technology in the classroom?	Quantitative questionnaire responses about teachers' attitudes towards technology (51-item TAC Questionnaire, which has been tested for reliability and validity by Christensen & Knezek (2009))	Descriptive statistics including frequencies, mean, median, mode, standard deviation
Based on the RAT framework, how is technology used in middle and high school mathematics classrooms?	Qualitative interview data about teachers' technology integration methods	Data from interviews were categorized in a table using the RAT framework (Hughes, Thomas, & Scharber, 2006)
In what ways do secondary mathematics teachers' use of technology in the classroom reflect their attitudes towards technology?	Qualitative interview data on teachers' technology integration methods and quantitative scores for teachers' attitudes towards technology	Categorized qualitative data were separated by TAC score for comparison of frequencies and trends

The data from the interviews were collected through audio recording and interviewer notes. These data were analyzed using the RAT model (Hughes et al., 2006) to explain how technology is being used in the classroom. The data were coded into the given themes of instructional methods, student learning processes, and curriculum goals, as seen in Table 3.2. Responses were then categorized as replacement, amplification, or transformation within the themes of instructional methods, student learning processes, or curriculum goals. The data were then analyzed to identify patterns that emerged.

Table 3.2 The RAT Model Template

		Categories for Technology Use		
		Replacement Technology is used to replace but not change any dimensions within the theme.	Amplification Technology is used to improve efficiency, effectiveness, and productivity but no fundamental changes are made to any dimensions within the theme.	Transformation Technology fundamentally changes tasks in new and original ways for one or more dimensions within the theme.
Themes	Instructional Methods • Teacher's role in instruction • Interaction with students • Assessment of students • Instructional preparation • Administrative tasks related to instruction (e.g. grading)			
	Student Learning Processes • Learning activity/task • Thinking process - mental process • Knowledge transfer • Task milieu (individual, small group, whole-class, others) • Student motivation • Student attitudes			
	Curriculum Goals • Curricular knowledge or concepts			

	• Curricular experiences • Curricular processes or procedures	

Data Management and Collection

All middle and high school mathematics teachers attended a professional development session on August 27, 2019 directed by the district coordinator of mathematics. During this session, the teachers were invited to participate in the study by completing a questionnaire about their attitudes towards technology. It was made clear to all teachers that participation was voluntary and that there were no rewards or penalties for participation or lack thereof. Teachers were asked to complete the questionnaire prior to the start of the session, during a break in the session, at the end of the session, or within two days following the session. This would allow teachers to take it at a convenient time and location without feeling pressured or watched as they complete it, if they decided to participate.

At the end of the questionnaire, teachers were given the opportunity to provide their names if they are willing to be interviewed about the use of technology in the classroom. It was made clear to all participants that the interview was not evaluative. The purpose was to understand the use of technology, not to critique any aspect of the instruction. The questionnaire information was used to identify teachers who were willing to be interviewed. Ideally, three teachers with the lowest mean scores on the TAC and three teachers with the highest mean scores on the TAC would be selected. However, the selection was dependent on the willingness of the respondents and their responses to the questionnaire. All teachers who provided their names were selected to be interviewed. Dates and times for the interviews were scheduled with each teacher.

During the interviews, with the permission of the participants, audio of the conversations was recorded using a handheld audio recording device, as well as a computer using an online audio recording program. In addition, the researcher took notes on paper, recording specific data such as what technology is being used for planning, instruction, and assessment and how the technology is used by students and teachers. Using multiple methods for recording data allowed the researcher to actively listen to responses with the assurance that the data was being collected accurately. The audio of the conversations was then transcribed. Each participant was given the opportunity to review the transcription of his or her interview to ensure the accuracy of statements and allow for clarification.

All data from both phases were stored in a secure, password-protected drive provided by the institution. Physical notes from the interviews were scanned and uploaded to the drive. Names and other identifying information were changed to protect the participants' identities.

Data Analysis and Procedures

For the first, quantitative phase of this mixed-methods study, the data analysis of the TAC questionnaire responses consisted of frequencies, mean, median, mode, and standard deviation. The data collected through the questionnaire was exported into a spreadsheet and data analysis software to allow for statistical analysis. The results were reported within tables, providing the descriptive statistics mentioned above for overall scores and the nine constructs. Frequency distributions allowed for each individual response to be seen while the measures of central tendency and standard deviation will show trends for the group as a whole.

The second, qualitative phase consisted of data from the interviews. Audio of each of the interviews was recorded using two separate devices. In addition, the interviewer took notes using a pen and paper. Upon transcription of the audio recordings for the second phase, each participant was invited to review the transcription of his or her interview to edit or clarify information. Once the transcriptions were reviewed, the data was coded. Structural coding was applied by using the research question to frame the data collection process (Saldaña, 2013). This method of coding used the research question to create the interview questions such that segments of data from the responses were categorized for further analysis. Data segments of similar categorization were then used for more detailed coding and analysis (Saldaña, 2013). This coding method was a good choice for this study because the RAT model provides the groups for sorting the data. Derived from the research question, the structural code is technology use in the mathematics classroom. Specific phrases describing activities in the classroom were grouped within the structural code using the themes (instructional methods, student learning processes, and curriculum goals) in the RAT model. Those phrases were then assigned to a category (replacement, amplification, or transformation) in the RAT model. One transcription was coded by the researcher. The same transcription was coded by another researcher using the same processes. The second researcher holds a Ph.D. in curriculum and instruction with a focus on mathematics education and has experience with qualitative research analysis. The results of both researchers were compared to ensure consistency and accuracy of the coding process. The researcher then coded the remaining seven transcripts using the same process as the first transcript. Together with the second researcher, the transcripts were reviewed so that all of the transcripts were coded in the same manner. Frequency tables were used to show the number of responses for each category and theme, as well as examples from interviews to provide more detailed information about individual responses (Saldaña, 2013). The qualitative data collected from the interviews were used to identify common themes among the group.

The final phase connected the quantitative and qualitative phases. The results from the qualitative phase were used to explain the results from the quantitative phase. Descriptive statistics from the quantitative data were used to indicate that the group of participants in the qualitative phase are representative of the whole group of participants in the quantitative phase. Connections between the teachers' attitudes towards technology and their technology integration methods were made by mixing the results for each of the nine constructs of the quantitative phase with the three themes (instructional methods, student learning processes, and curriculum goals) of the RAT model in the qualitative phase. Then, connections were made between the teachers' attitudes towards technology and their technology integration methods by mixing the results for each of the nine constructs of the quantitative phase with the three categories (replacement, amplification, and transformation) of the RAT model in the qualitative phase. The ways, or themes, and the levels, or categories, teachers indicated using technology in their classrooms were used to explain their attitudes towards technology, as indicated on the questionnaire.

Ethical Considerations

All participants in this study understood that all data were kept private during and after the study was concluded. It was clearly explained to all participants that they would remain anonymous and any personal information would be confidential. All personally identifiable information was changed prior to any sharing of data with any member of the school system or university other than the researcher. Participants of the study understood that they would not be impacted negatively or positively with regard to professional matters due to participation or lack thereof, nor would they benefit financially or be penalized for lack of participation.

Limitations

This study included mathematics teachers who work in middle and high school math classes in a rural school district in the Mid-Atlantic region of the United States. The sample of teachers in the study was small and not random due to the size of the school system. The study was limited to the teachers who were willing to participate in one or both phases of the study. It is possible that teachers who were less confident with technology were apprehensive to participate in the qualitative phase of the study. The school district was in the process of changing learning management systems so this change could have had an impact on the attitudes toward technology. The change may have caused frustration for some teachers, while others looked forward to a new system and welcomed the change. Donovan, Hartley, and Strudler's (2007) study showed more than half of teachers had high personal concerns about the 1:1 implementation at their school. The results of this study cannot be used to make generalizations to other content areas, grade levels, or school districts because the study was specific to middle and high school math teachers in one school district. The results may not reflect possible outcomes of other content areas or grade levels in the same district.

Chapter 3 Summary

This study examined the relationship between teachers' attitudes towards technology and the ways in which they integrate it into their classrooms. A questionnaire was used to collect quantitative data to assess the attitudes of middle and high school mathematics teachers in a rural school system in the Mid-Atlantic region of the United States. Eight teachers indicated a willingness to participate in the qualitative phase. These teachers were interviewed about their technology integration methods and strategies to examine how they integrate technology. The data was analyzed to determine if the practice of their technology integration reflected mathematics teachers attitudes towards technology.

CHAPTER FOUR: RESULTS

Introduction

This mixed methods study aimed to examine the technology integration of middle and high school mathematics teachers and their attitudes towards technology. The main purpose was to understand if there is a relationship between secondary mathematics teachers' attitudes towards technology as indicated in the Teachers' Attitudes Toward Computers (TAC) Questionnaire and how they use technology in their classrooms from the participants' perspectives. One of the two sub-questions was used to identify the attitudes of the teachers, while the other was used to identify how they use technology in the classroom. The main research question was:

- In what ways do secondary mathematics teachers' use of technology in the classroom reflect their attitudes towards technology?

The sub-questions used to answer the main research question were:

- What are the attitudes of secondary school mathematics teachers towards technology in the classroom as measured by the Teachers' Attitudes Toward Computers (TAC) Questionnaire?
- Based on teachers' interviews, how is technology used in secondary school mathematics classrooms when viewed through the lens of the RAT framework?

This study included quantitative data from 28 middle and high school mathematics teachers in a small, rural school district in the Mid-Atlantic region of the United States to assess the attitudes of the teachers towards technology and qualitative data regarding technology integration in mathematics classrooms from interviews with eight volunteers from the quantitative phase.

The results of this study are presented in three phases that address the three research questions. To answer the first research question, descriptive statistics from the quantitative data are presented. The data reflects the participants' attitudes towards and beliefs about technology. To answer the second research question, the data and analysis from the interviews is presented, providing insight into how technology is used in the classrooms of the interview participants. Finally, to answer the last research question, the quantitative and qualitative data are merged to analyze the ways in which secondary mathematics teachers' use of technology in the classroom reflects their attitudes towards and beliefs about technology.

Phase I: Quantitative Results

The intention of the quantitative phase of this study was to answer the first research sub-question: What are the attitudes and beliefs of secondary school mathematics teachers towards technology in the classroom as measured by the Teachers' Attitudes Toward Computers (TAC) Questionnaire? Invitations to participate in the TAC questionnaire and reminder emails were sent to participants through their school district email. They were given five weeks to participate. As no incentives for participants were included in this study, teachers were encouraged to participate through an appeal to goodwill. Reminders were sent at the beginning of week 3 and week 5. Twenty-eight teachers participated in the questionnaire. The results of the questionnaire are provided below beginning with a review of the participants and their demographics followed by the overall scores for each of the nine constructs. This is followed by a detailed review of the outcomes for each of the nine constructs. The discussion of the results can be found in chapter five.

<u>Questionnaire Participants</u>

Twenty-eight out of the fifty middle and high school mathematics teachers in the district participated in the TAC questionnaire, providing a 56% response rate. As Baruch and Holtom (2008) suggest, about 53% is a common response rate for surveys used in organizational research. The 56% response rate for this study was higher than the pilot study by the same researcher of teachers in this school district. In addition to the email communication, during a face-to-face professional development session, the researcher invited teachers to participate in this study whereas the previous study only requested participation through email. Including the face-to-face request, may have garnered a higher participation rate as suggested by Nulty (2008). Although, the grade level at which the participants teach is almost evenly split with 46.4% at the middle school level and 53.6% at the high school level, the years of experience varied (Table 4.1).

Table 4.1 Demographic Information of Participants

	Frequency	Percent
Grade Level		
Middle School (grades 6 – 8)	13	46.4
High School (grades 9 – 12)	15	53.6
Years of Experience		
0 – 4 years	3	10.7
5 – 10 years	4	14.3
11+ years	21	75

Note. N = 28.

Nine Constructs

The TAC questionnaire consisted of 51 questions in nine constructs: interest, comfort, accommodation, interaction, concern, utility, perception, absorption, and significance (Table 4.2). Eight of the constructs (interest, comfort, accommodation, interaction, concern, utility, absorption, and significance) were measured on a Likert scale of 1 to 5, where 1 represented “strongly disagree” and 5 represented “strongly agree” with 3 representing “undecided”, which is interpreted as a neutral response for this study. Three of those eight constructs contained questions that were worded in such a way that a score of 1 represented a positive attitude while a score of 5 represented a negative attitude. These scores were re-coded such that a score of 1 was recorded as 5, 2 as 4, 4 as 2, and 5 as 1. In this way, a lower score represented a negative attitude and a higher score represented a positive attitude for the analysis of all questions.

The overall mean scores for each participant were then calculated by adding the mean scores for each construct and dividing by 9, the total number of constructs. The lowest possible mean was 1, while the highest score was 5. In a study involving student attitudes toward Calculus using a 5-point Likert scale questionnaire, Yimer and Feza (2019) calculated the students’ total scores and created three intervals, “agree”, “neutral”, and “disagree”. In a similar manner, five intervals were created by dividing the range of 1 – 5 by 5 to create equal intervals (Very Low, Somewhat Low, Neutral, Somewhat High, and Very High) for comparison purposes. Overall mean scores were then categorized and the frequencies were recorded, as shown in Table 4.2. The overall mean scores are appropriate for Likert scale scores because they are calculated from a composite score and can thus be analyzed on a interval measurement scale (Boone & Boone, 2012).

Table 4.2 Frequency Table of Intervals of Overall Mean Scores

Interval	Mean Overall Score	Frequency
Very Low	1.00 – 1.80	0
Somewhat Low	1.81 – 2.60	1
Neutral	2.61 – 3.40	8
Somewhat High	3.41 – 4.20	14
Very High	4.21 – 5.00	5

Note. N = 28.

The construct Perception was measured on a scale of 1 to 7, where 1 represented an unfavorable adjective and 7 represented a favorable adjective. In order to compare these scores to those of the other constructs, a transformation is needed (Little, 2013). The scores for each of the questions in this construct were re-coded using the formula $x_2 = (4/6) * x_1 + (2/6)$, where x_1 is the original score and x_2 is the new score (IBM, n.d.). This formula allows an original score of 1 to produce a new score of 1 and an original score of 7 to produce a new score of 5. The overall mean scores for the participants of this study, found by calculating the mean score of all nine mean construct scores for each participant, ranged from 1.85 to 4.72 with an average of 3.66, indicating an overall attitude for the group on the positive side of the scale (Table 4.3). The lowest mean scores for the constructs, interaction with 2.86 and absorption with 2.96, indicate a neutral attitude.

Table 4.3 Descriptive Results for Constructs of Attitudes and Beliefs

	Mean	Std. Deviation
InterestAvg	3.70	.83
ComfortAvg	3.19	.80
AccommodationAvg	4.70	.50
InteractionAvg	2.86	.77
ConcernAvg	3.19	.80
UtilityAvg	4.05	.58
PerceptionAvg	3.86	.84
AbsorptionAvg	2.96	.75
SignificanceAvg	4.44	.51
OverallAvg	3.66	.57

Note. N = 28.

Interest

The interest in using computers was the focus of this construct. The questions related to the participants' enjoyment of and desire to work with, learn on, and learn about computers. The mean score for each question in this construct was above 3, indicating a positive attitude with regard to interest when using computers (Table 4.4). Question 4 "I like learning on a computer" had the lowest mean, 3.14, median, 3, and mode, 3, in this construct.

Table 4.4 Descriptive Results for Interest

	Interest Q1	Interest Q2	Interest Q3	Interest Q4	Interest Q5
Mean	3.96	3.79	3.64	3.14	3.96
Median	4.00	4.00	4.00	3.00	4.00
Mode	4	4	4	3	4
Std. Deviation	.793	.995	1.062	1.208	.922

Note. N = 28.

Comfort

Comfort in using computers was the focus of this construct. The questions related to the participants' feelings of comfort when using computers. The questions were worded negatively, such that a high score indicated a high level of discomfort or anxiety. Therefore, the scores were re-coded for the purposes of comparison between constructs. Overall, the average scores were above 4, indicating a positive attitude toward feelings of comfort with using computers (Table 4.5). However, question 5, "Using a computer is frustrating", had a slightly lower average of 3.79, which is indicates a positive attitude.

Table 4.5 Descriptive Results for Comfort

	Comfort Q1	Comfort Q2	Comfort Q3	Comfort Q4	Comfort Q5
Mean	4.25	4.18	4.21	4.04	3.79
Median	4.00	4.00	4.00	4.00	4.00
Mode	4	4	4	4	4
Std. Deviation	.645	.723	.833	.999	1.067

Note. N = 28.

Accommodation

Adapting to the use of computers was the focus of this construct. The questions related to the participants' feelings towards adapting to the use of computers in the workplace and life in general. The questions were worded negatively, such that a high score indicated a high level of resistance to computers. Therefore, the scores were re-coded for the purposes of comparison between constructs. After the re-coding, all of the questions had an average score above 4, indicating a low resistance to adapting to the use of computers (Table 4.6). Question 2 "Studying about computers is a waste of time" had the lowest mean, 4.32, and median, 4. It also had two modes, 4 and 5, while the other questions all had a mode of 5. Question 4 "I will probably never learn to use a computer" had the highest mean after the re-coding process, 4.86, and the lowest standard deviation, .356, indicating that teachers feel they will learn to use a computer and that their answers were not widely spread.

Table 4.6 Descriptive Results for Accommodation

	Acc. Q1	Acc. Q2	Acc. Q3	Acc. Q4	Acc. Q5
Mean	4.75	4.32	4.75	4.86	4.82
Median	5.00	4.00	5.00	5.00	5.00
Mode	5	4[a]	5	5	5
Std. Deviation	.645	.863	.799	.356	.612

Note. N = 28.
a. Multiple modes exist. The smallest value is shown.

Interaction

The focus of this construct was communication or interaction with other people through the use of email. The questions relate student learning to the use of email as a means of communication. This construct had the lowest mean score, 2.86, out of all nine constructs. This indicates that the participants had a neutral attitude toward the use of email with students. Question 3 “The use of E-mail makes a class more interesting”, question 4 “The use of E-mail helps the student learn more”, and question 5 “The use of E-mail increases motivation for class” had the lowest individual mean scores or 2.57, 2.57, and 2.64, respectively (Table 4.7). Question 4 also had the lowest mode, 2, and median, 2.50. One of the mean scores were on the somewhat high side of the scale, while two were neutral and two more were on the somewhat low side of the scale. In the school district of this study, students do not have a district e-mail account so that particular method of communication may not be used frequently by the participants of the study, which could lower the scores for the questions in this construct.

Table 4.7 Descriptive Results for Interaction

	Interaction Q1	Interaction Q2	Interaction Q3	Interaction Q4	Interaction Q5
Mean	3.43	3.11	2.57	2.57	2.64
Median	3.50	3.00	3.00	2.50	3.00
Mode	4	3	3	2	3
Std. Deviation	.959	.875	.836	.879	.870

Note. N = 28.

Concern

Concern for the societal and personal changes due to the use of computers was the focus of this construct. The questions related to the participants’ feelings about the social and emotional effects of technology on individuals and society. The questions were worded negatively, such that a high score indicated a high level of concern about the negative effects of computers. Therefore, the scores were re-coded for the purposes of comparison between constructs. After the re-coding, four of the questions had average scores that are less than three, which indicated "undecided" in the five-point scale of the questionnaire (Table 4.8).

Question 5 "Computers isolate people by inhibiting normal social interactions among users" had the lowest mean score of 2.32, which indicates a negative attitude, while question 7 "Computers have the potential to control our lives" following with a mean score of 2.68, which is neutral. Question 1 "Computers are changing the world too rapidly" and question 4 "Our country relies too much on computers" had mean scores of 2.86 and 2.93, respectively, which were also neutral. All four of these questions had a mode of 2. They also had a mode of 2, except question 4, which had a mode of 3.

Table 4.8 Descriptive Results for Concern

	Concern Q1	Concern Q2	Concern Q3	Concern Q4	Concern Q5	Concern Q6	Concern Q7	Concern Q8
Mean	2.86	4.04	3.64	2.93	2.32	3.50	2.68	3.54
Median	2.00	4.00	4.00	3.00	2.00	4.00	2.00	4.00
Mode	2	4	4	2	2	4	2	4
Std. Deviation	1.113	.881	1.193	1.245	.945	1.036	1.249	1.071

Note. N = 28.

Utility

This construct focuses on the usefulness of computers in education and everyday life. The questions related to how computers can be used to help in different aspects of learning and working, including efficiency, effectiveness, and productivity. All of the mean scores for the questions in this construct were in the "somewhat high" or "very high" intervals, indicating a positive attitude toward the usefulness of computers (Table

4.9). There were three questions that had a mean score of less than 4, which indicated, "agree". Question 5 "Computers improve the overall quality of life", 6 "If there was a computer in my classroom it would help me to be a better teacher", and 8 "Computers will improve education", had mean scores of 3.82, 3.93, and 3.79, respectively.

Table 4.9 Descriptive Results for Utility

	Utility Q1	Utility Q2	Utility Q3	Utility Q4	Utility Q5	Utility Q6	Utility Q7	Utility Q8
Mean	4.11	4.07	4.36	4.32	3.82	3.93	4.00	3.79
Median	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Mode	4	4	4	5	4	4	4	4
Std. Deviation	.685	.716	.678	.772	.905	.900	.667	.738

Note. N = 28.

Perception

Perceptions of computers were the focus of this construct. The questions provided two antonyms describing computers. Participants selected a rating from 1 to 7 based on their feelings toward computers. The negative adjective was to the left of the number 1, while the positive adjective was to the right of the number 7. The scores for each of these questions were recoded using the formula $x_2 = (4/6) * x_1 + (2/6)$, where x_1 is the original score and x_2 is the new score (IBM, n.d.). This formula allows an original score of 1 to produce a new score of 1 and an original score of 7 to produce a new score of 5. After re-coding, all of the questions had a mean score higher than 3 and a median of 3.67, except question 1, which had a median of 4.33. Question 2 "Computers are suffocating…fresh" had two modes, the lowest of which was 3 (Table 4.10). This indicates that the participants had a positive attitude towards their perceptions of computers.

Table 4.10 Descriptive Results for Perception

	Perception Q1	Perception Q2	Perception Q3	Perception Q4	Perception Q5
Mean	4.10	3.74	3.71	3.86	3.88
Median	4.33	3.67	3.67	3.67	3.67
Mode	4.33	3.00[a]	3.67	3.67	3.67
Std. Deviation	.874	.949	.976	.991	.995

Note. N = 28.
a. Multiple modes exist. The smallest value is shown.

<u>Absorption</u>

The focus of this construct was how computers have been integrated into how the participant spends their time, the level of engagement they have with computers. The questions focus on the use of discretionary time spent on computers. All of the questions had mean scores above 3 except question 1 “I like to talk to others about computers” and question 4 “I like reading about computers”, which had mean scores of 2.86 and 2.21, respectively (Table 4.11). Question 4 also had the lowest median, 2, and standard deviation, .995. Therefore, this question had the least amount of variability in the responses. This indicates that the participants had a neutral attitude towards spending discretionary time engaging with computers, in general, and a negative attitude towards reading about computers and talking to others about them.

Table 4.11 Descriptive Results for Absorption

	Absorption Q1	Absorption Q2	Absorption Q3	Absorption Q4	Absorption Q5	Absorption Q6
Mean	2.86	3.14	3.29	2.21	3.04	3.25
Median	3.00	3.50	4.00	2.00	3.00	4.00
Mode	2[a]	4	4	2	2	4
Std. Deviation	1.145	1.239	1.272	.995	1.138	1.110

Note. N = 28.
a. Multiple modes exist. The lowest value is shown.

Significance

The worth or importance of computers is the focus of this construct. The questions focus on the value of computers in education, the workplace, and society. All of the questions had a mean score above 4, indicating a positive belief about the significance of computers (Table 4.12). Question 5 "Computers could stimulate creativity in students" had the lowest mean, 4.21, median, 4, and mode, 4. It also had the highest standard deviation, .738, indicating a higher variability in the responses.

Table 4.12 Descriptive Results for Significance

	Significance Q1	Significance Q2	Significance Q3	Significance Q4	Significance Q5
Mean	4.43	4.50	4.54	4.54	4.21
Median	4.50	4.50	5.00	5.00	4.00
Mode	5	4[a]	5	5	4
Std. Deviation	.690	.509	.508	.693	.738

Note. N = 28.
a. Multiple modes exist. The smallest value is shown.

Summary of Quantitative Results

The purpose of the quantitative phase of this study was to answer the first research sub-question: What are the attitudes and beliefs of secondary school mathematics teachers towards technology in the classroom as measured by the Teachers' Attitudes Toward Computers (TAC) Questionnaire? The overall mean scores for the participants of this study ranged from 1.85 to 4.72. Only one of the scores was in the somewhat low interval, while eight were in the neutral interval. Therefore, 19 of the mean scores of the participants are in the somewhat high or very high intervals. This indicates that the majority of the participants have positive attitudes and beliefs towards technology. The only two constructs in which the overall mean score was on the neutral interval of the spectrum, between 2.61 and 3.40, were interaction, with a score of 2.86, and absorption, with a score of 2.96. This indicates that, while the participants have an overall positive attitude towards technology, they had neutral attitudes towards the effect of computers on people and society and spending their discretionary time learning more about computers.

Phase II: Qualitative Results

The intention of the qualitative phase of this study was to answer the second research sub-question: Based on teachers' interviews, how is the technology used in secondary school mathematics classrooms when viewed through the lens of the RAT framework? Invitations to participate in the interview were presented at the end of the TAC questionnaire. Participants were given the opportunity to provide their name and email address if they were willing to be interviewed about their use of technology in the classroom. No incentives for participants were included in this study so teachers were encouraged to participate through an appeal to goodwill. Interviews were scheduled and conducted at the participants' convenience. The one-on-one interviews took place over the course of one month. Eight teachers participated in the interviews. The results of the interviews are provided below beginning with a review of the participants and their demographics followed by the overall results of the interviews. Further discussion of the results can be found in the next chapter.

Interview Participants

Of the twenty-eight teachers who participated in the TAC questionnaire, eight provided their names for interviews. All eight participated in the interview phase. As shown in Table 4.13, four of them taught at the high school level while the other four teach middle school. The years of experience was 11 years or more for seven of the participants, while the remaining participant had taught for less than 5 years. The interview participants' overall mean scores on the quantitative survey ranged from 3.53 to 4.72. All of those interviewed had overall mean scores that fell on the positive side of the scale. Therefore, two distinct groups could not be formed from the interview participants.

Table 4.13 Demographic Information of Interview Participants

	Frequency	Percent
Grade Level		
Middle School (grades 6 – 8)	4	50.0
High School (grades 9 – 12)	4	50.0
Years of Experience		
0 – 4 years	1	12.5
5 – 10 years	0	0
11+ years	7	87.5

Note. N = 8.

<u>First Cycle of Coding</u>

Structural coding (Saldana, 2013) was used for the first cycle of coding because the themes of the Replacement-Amplification-Transformation (RAT) model were used to create the interview questions such that the responses would be easily coded into those themes. This coding structure also allows the frequency of references to each theme to be recorded. The overall themes were categorized as instructional methods, student learning processes, and curriculum goals. For each of the themes, examples from the responses are shown in Table 4.14. Within the category of instructional methods, the themes were the teacher's role in instruction, interaction with students, assessment of students, instructional preparation, and administrative tasks related to instruction. Eighty-five of the 168 references were coded as instructional methods, which tend to be more teacher-centered activities. This is approximately 51% of all the references. The themes of learning tasks or activities, thinking processes, knowledge transfer, task milieu, student motivation, and student attitudes were included in the category of student learning processes, which tend to be more student-centered activities. Sixty-eight of the 168 references were coded as student learning processes, which is about 40% of the total references. The category of curriculum goals includes themes of curricular knowledge or concepts, curricular experiences, and curricular processes and procedures. Fifteen of the 168 references were coded as curriculum goals, only about 9% of all the references. Refer to Table 4.15 for a frequency table of references.

Table 4.14 Examples of First Round Data Coding

	Themes	Examples
Instructional Methods	Teacher’s role in instruction	Lecture/Delivery of notes Demonstration of concepts
	Interaction with students	Asking questions/polling students Providing feedback
	Assessment of students	Formative assessment (e.g. warm-ups, exit tickets) Summative assessment (e.g. quizzes, tests)
	Instructional preparation	Planning lecture/notes Planning learning activities Creating assessments
	Administrative tasks related to instruction (e.g. grading)	Grading assessments Attendance Displaying agenda
Student Learning Processes	Learning activity/task	Note-taking Card sorts Typing for mathematics
	Thinking process - mental process	Self-assessment Error Analysis Application of Concepts
	Knowledge transfer	Textbook Video lessons
	Task milieu (individual, small group, whole-class, others)	Differentiated learning groups Menu math Whole class instruction
	Student motivation	Gamification

		Personalized learning experiences
	Student attitudes	Ownership of learning
Curriculum Goals	Curricular knowledge or concepts	Visualization of concepts
	Curricular experiences	Conceptual activities Animations
	Curricular processes or procedures	Concurrent courses Access to content/curriculum documents

Second Cycle of Coding

The second cycle of coding further categorized the references by the level of the use of technology through the three categories that comprise the RAT model, replacement, amplification, and transformation. Responses that reflected the use of technology as a replacement but did not change any dimensions within the theme were coded as “replacement”. Responses that reflected the use of technology as improving efficiency, effectiveness, and productivity but with no fundamental changes to any dimensions were coded as “amplification” while responses that reflected the use of technology as fundamentally changing a task in new and original ways for at least one dimension were coded as “transformation”.

The majority of the references, shown in Table 4.15, were coded as amplification with the most in the theme of instructional methods (56), followed by student learning processes (41) with significantly less in curriculum goals (10). The total number of references for amplification was 107, which was almost 64% of all the references. There were also a significant number of references that were categorized as “replacement”.

These references followed a similar pattern as those in instructional methods (29) with the most instructional methods, just a couple less in student learning processes (27), and the least in curriculum goals (5). So the total number of references for replacement was 61, which is 46 less than those for amplification or about 36% of all the references. None of the references were coded as a transformational use of technology.

Table 4.15 Frequency and Percentage Table of Qualitative Data in the RAT Model

		Frequencies in Categories for Technology Use			
		Replacement Technology is used to replace but not change any dimensions within the theme.	Amplification Technology is used to improve efficiency, effectiveness, and productivity but no fundamental changes are made to any dimensions within the theme.	Transformation Technology fundamentally changes tasks in new and original ways for one or more dimensions within the theme.	Total
Themes	Instructional Methods	29 (17%)	56 (33%)	0 (0%)	85 (51%)
	Student Learning Processes	27 (16%)	41 (24%)	0 (0%)	68 (40%)
	Curriculum Goals	5 (3%)	10 (6%)	0 (0%)	15 (9%)
	Total Frequency	61 (36%)	107 (64%)	0 (0%)	168 (100%)

<u>Summary of Qualitative Data Results</u>

The purpose of the qualitative phase of this study was to answer the second research sub-question: Based on teachers' interviews, how is the technology used in secondary school mathematics classrooms when viewed through the lens of the RAT framework? The eight interview participants were evenly split between the middle and high school level, while all but one had eleven or more years of experience. The percentages of references for each theme were as follows, 51% instructional methods, 40% student learning processes, and 9% curriculum goals. This indicates that the interview participants use technology more for instructional methods (teacher-centered activities) than student learning processes (student-centered activities) or curriculum goals. However, student-learning processes comprised a large portion of the references so teachers are using technology to support these processes . The percentages of references for the categories or levels of technology use were as follows, 36% replacement, 64% amplification, and 0% transformation. This indicates that the participants are using technology to improve efficiency, effectiveness, and productivity more than half of the time they are using technology in the classroom but are not making fundamental changes to any dimensions within the theme.

Phase III: Combined Results

The intention of the combined results phase of this study was to answer the main research question: In what ways do secondary mathematics teachers' use of technology in the classroom reflect their attitudes and beliefs towards technology and its use? The quantitative results for the interview participants were reviewed and it was determined that there did not exist two distinct groups of varying attitudes towards technology. Therefore, the combined results were examined holistically. The combined results are provided below beginning with a review of the quantitative results of the participants. Further discussion of the results can be found in the next chapter.

Quantitative Results of the Interview Participants

The overall mean scores on the TAC questionnaire were reviewed for each interview participant and were found to range from 3.53 to 4.72 (Table 4.16). The participants' scores for each construct were found by calculating the mean of the scores for all the questions in that construct. The overall mean score for each participant was found by calculating the mean of all the construct scores for the participant. Although the mean scores for each construct and the overall mean score were higher for the small group of qualitative participants than the whole group of quantitative participants, the average scores for each construct follow a similar pattern to the average scores for all of the participants in the quantitative phase. For example, in both groups, the two constructs with the lowest average scores were absorption and interaction. The main difference is that the interview participants had a lower average score for absorption, which was 3.21, than interaction, which was 3.23. The whole group of quantitative participants had a lower average score for interaction, which was 2.86, than that for absorption, which was 2.96. This does not indicate a difference in the attitudes of the participants regarding these constructs, as they are neutral. All of the other constructs follow the same pattern with regard to the ordering of the mean scores for each construct. Both groups had the highest mean score in accommodation. Therefore the small group interview participants' attitudes towards technology reflect the attitudes of the whole group of quantitative participants.

Table 4.16 Descriptive Results for Each Construct of Interview Participants

	Minimum	Maximum	Mean	Std. Deviation
InterestAvg	3.40	5.00	4.25	.563
ComfortAvg	3.00	5.00	3.70	.658
AccommodationAvg	4.20	5.00	4.80	.321
InteractionAvg	2.60	5.00	3.23	.774
ConcernAvg	3.00	5.00	3.70	.658
UtilityAvg	3.75	5.00	4.44	.513
PerceptionAvg	3.53	5.00	4.32	.590
AbsorptionAvg	2.00	4.17	3.21	.700
SignificanceAvg	4.20	5.00	4.75	.366
OverallAvg	3.53	4.72	4.04	.425

Note. N = 8.

Mean Scores for Constructs and Interview Themes

Overall the construct mean scores for the interview participants showed a positive attitude towards computers. The highest mean scores were in the constructs of accommodation, significance, and utility while the majority of the interview responses were coded as instructional methods. A high score for accommodation, which is related to the participants' feelings towards adapting to the use of computers in the workplace and life in general, is consistent with an emphasis on instructional methods, as teachers are being required to use computers in the classroom. They appear to learn to use them for instructional methods where they have more control over the technology. A high score in significance, which focused on the value of computers in education, the workplace, and society, with a frequent use of technology for instructional methods indicates that teachers recognize the value in using technology for teaching purposes. A high score in utility, which is related to how computers can be used to help in different aspects of learning and working, and a high frequency for technology use in instructional methods demonstrates that teachers recognize how technology helps improve instruction.

The lowest mean scores were in the constructs of comfort, concern, absorption, and interaction. The lower scores in comfort and concern, which refer to the participants' feelings about the social and emotional effects of technology on individuals and society, are consistent with a lower frequency for using technology for student learning processes. Teachers may be less likely to use technology for student-centered activities if they do not feel comfortable with the technology or if they are concerned about potential negative effects that technology will have on their students. A low score in absorption, which focuses on the use of discretionary time spent on computers, with a lower frequency of using technology for student learning processes indicates that while teachers may spend time learning to use technology for instruction, it may require more time to apply it to student learning. A low score on interaction, which relates student learning to the use of email as a means of communication, with a lower frequency for the use of technology for student learning processes may indicate that digital communication with students for learning purposes may not be as valued. However, it may be that the method of communication that is not as highly valued.

Mean Scores for Constructs and Interview Categories

The participants' attitudes towards technology are reflected by their responses to the categories or levels of technology use. While 36% of the participants' responses were coded as replacement, 64% were coded as amplification. This is indicative of a positive attitude towards technology. The participants' high scores in accommodation, significance, utility, interest, and perception are reflected by the use of technology to amplify the activity or task by adding efficiency, effectiveness, and/or productivity rather than simply replacing it using technology. However, participants did not indicate any uses of technology that were coded as transformation. The tendency to replace or amplify tasks and activities rather than transform them with technology by fundamentally changing the task or activity can be connected to their lower score in comfort as teachers may not be as comfortable with technology so they may be hesitant to make more drastic changes. It also reflects their lower score in concern as teachers may worry that using technology to fundamentally change tasks or activities so that the technology is required may encourage dependence on technology and discourage student interaction and collaboration.

Summary of Combined Results

The purpose of the combined results phase of this study was to answer the main research question: In what ways do secondary mathematics teachers' use of technology in the classroom reflect their attitudes and beliefs towards technology? The higher percentage of using technology for instructional methods can be connected to the participants' positive attitudes toward technology, in general. While the lower percentage for using technology for student learning processes could be a reflection of their less positive attitudes with regard to comfort, concern, absorption, and interaction. The majority of technology use was coded as amplification, which reflects the participants' high scores in accommodation, significance, utility, interest, and perception, while the lack of frequencies coded as transformation reflects the less positive attitudes regarding comfort and concern.

Chapter 4 Summary

The results of the quantitative TAC questionnaire, the qualitative interviews using the RAT model, and the mixing of these methodologies were reviewed in this chapter. The quantitative phase was presented using descriptive statistics for each of the nine constructs and the combination of the constructs to address the first research sub-question, while the qualitative phase examined the interview responses in light of the themes and categories of the RAT model to address the second research sub-question. The final phase combined the two sets of data together to address the main research question. The discussion of the conclusions and implications of the research will be addressed in the next and final chapter.

CHAPTER FIVE: DISCUSSION

Introduction

As school systems work to increase the availability and use of technology, the constantly changing nature of technology creates challenges. In addition, the barriers of teachers' negative attitudes and beliefs towards technology may hinder the integration of technology in the classroom (Vongkulluksn et al., 2018). Administrators and teachers can address the issue and work toward positive change by understanding the relationship between these two concepts. The purpose of this mixed methods study was to investigate the attitudes and beliefs towards technology of secondary mathematics teachers and their technology integration.

In this chapter, the results of this study are discussed in further detail and connected to literature relating to the attitudes towards technology and technology integration of mathematics teachers. This will allow for the exploration of the implications of attitudes of mathematics teachers toward technology as those attitudes relate to their technology integration. It allows for suggestions to be made with regard to improving the attitudes towards technology and supporting teachers in their integration of technology.

Discussion of Findings

Research Sub-Question One

The first research sub-question asked: What are the attitudes and beliefs of secondary school mathematics teachers towards technology in the classroom as measured by the Teachers' Attitudes Toward Computers (TAC) Questionnaire? The quantitative results of the overall mean scores on the TAC questionnaire for this study had a mean of 3.66. The range of possible scores was 1 – 5. The overall mean score (M = 3.66) indicates that the teachers in the study had generally positive attitudes towards technology in the classroom with the highest mean score in accommodation (M = 4.70) and the lowest in interaction (M = 2.86). Therefore, the range in mean scores for the constructs was 2.86 – 4.70.

For this study, the interpretation of the scores is based on the highest and lowest possible scores available because the TAC does not currently have quartiles in which to rate the total mean scores or the mean scores of the constructs. The range of 1 – 5 was divided by 5 to create equal intervals (Very Low, Somewhat Low, Neutral, Somewhat High, and Very High) for comparison purposes. This is consistent with the design of the TAC questionnaire as there were five possible responses (Strongly Disagree, Disagree, Undecided, Agree, and Strongly Agree) for each of the questions (Table 5.1) except the construct of perception, which had seven possible responses. However, the responses for perception were re-coded to a range of 1 – 5 to maintain consistency in analysis (Little, 2013). The scores for each of the questions in this construct were transformed using the formula $x_2 = (4/6) * x_1 + (2/6)$, where x_1 is the original score and x_2 is the new score (IBM, n.d.). This formula allows an original score of 1 to produce a new score of 1 and an original score of 7 to produce a new score of 5. In addition, due to the wording of the questions, three of the constructs were also recoded to align the negative responses with the lower scores so a 5 was coded as a 1, a 4 was coded as a 2, a 2 was coded as a 4, and a 1 was coded as a 5.

Using the intervals created, Table 5.1 shows the majority of the scores are either Somewhat High or Very High . The overall mean for all of the participants was 3.66 and the median was 3.76, both of which fall in the Somewhat High interval. Therefore, on average, participants had a positive attitude towards technology in the classroom overall. These findings are consistent with Albirini's study (2006), which, using a similar 5-point scale questionnaire, found that teachers had a positive or highly positive attitude toward computers.

Table 5.1 Frequency Table of Intervals of Mean Overall Scores

Interval	Mean Overall Score	Frequency
Very Low	1.00 – 1.80	0
Somewhat Low	1.81 – 2.60	1
Neutral	2.61 – 3.40	8
Somewhat High	3.41 – 4.20	14
Very High	4.21 – 5.00	5

Note. N = 28.

The same intervals can be used to analyze the mean scores for the constructs since the questions used the same scale. Four of the constructs had mean scores that fell in the Neutral category: interaction (M = 2.86), absorption (M = 2.96), comfort (M = 3.19), and concern (M = 3.19). This is similar to the findings of Green (2015) in a study of 25 K-12 teachers. His study had three constructs with mean scores lower than 4, absorption (M = 3.27), interaction (M = 3.29), and concern (M = 3.42). The rest of the mean scores were higher than 4. Three of the constructs had mean scores that fell in the Somewhat High category: interest (M = 3.70), perception (M = 3.86), and utility (M = 4.05). The final two constructs had mean scores that fell in the Very High category: significance (M = 4.44) and accommodation (*M* = 4.70). Based on these results, it may be necessary to focus on the constructs of interaction, absorption, comfort, and concern to improve the attitudes of middle and high school mathematics teachers in the district towards technology in the classroom.

In general, creating these intervals provides a better understanding of how the participants self-assess their attitudes towards technology in the classroom and where potential growth could take place. Surveying teachers before and after providing targeted professional development and specific support may offer insight as to what changes may improve attitudes towards technology. Questionnaire scores could be gathered and compared across departments within the district to allow for an understanding of the attitudes among the entire school system. In addition, questionnaire scores for middle and high school mathematics teachers could be gathered and compared across school systems to better understand the attitudes of this population in general. This study presents an initial look at the attitudes toward technology within a particular school system among a specific population of teachers and the results may offer a baseline for future research, which is further discussed later in this chapter.

Research Sub-Question Two

The second research sub-question asked: Based on teachers' interviews, how is technology used in secondary school mathematics classrooms when viewed through the lens of the RAT framework? The RAT framework separates the data into three themes of instructional methods, student learning processes, and curriculum goals. Within those themes the data is categorized as replacement, amplification, or transformation. Based on the data analysis, the eight teachers who participated in qualitative phase of this study, use technology more for instructional methods such as delivery of notes, demonstration of concepts, polling students, providing feedback to students, assessing student learning, planning classes, and creating and grading assessments. Student learning processes such as note-taking, card sorts, self-assessment, error analysis, application of concepts, accessing textbooks and video lessons, working in differentiated learning groups, menu math, whole class instruction, and personalized learning experiences were also mentioned often in the responses. A few of the responses mentioned were categorized as curriculum goals, which includes visualization of concepts, conceptual activities, animations, concurrent courses, and access to content/curriculum documents. These findings indicate that the technology use of the teachers in the study who were interviewed is more focused on the teachers than the students.

When the data was coded again for the level of use, 64% of the responses indicated an amplification of activities, which means that the use of technology increased efficiency, effectiveness, and/or productivity. While only 36% of the responses indicated a replacement of activities, meaning that the use of technology did not enhance the activity and that it simply replaced another method that did not use technology, none of the responses indicated a transformation of the activity. This means that the teachers who participated in this phase of the study were not using technology to fundamentally change an instructional method, student learning experience, or curriculum goal. These results are consistent with the existing research that amplification is the most common use of technology in the classroom while transformation is the least common use (Hughes et al., 2017; Bozkurt et al., 2014).

The qualitative data provides a better understanding of how the participants use technology in the classroom and where potential growth could take place. Providing professional development and support that specifically focuses on how to increase the level of technology integration based on the RAT model may increase the level of integration in the classroom (Bozkurt et al., 2014; Ardic & Isleyen, 2017). Interviewing teachers before and after the profession development sessions and time for implementation may offer insight as to what methods may improve levels of technology integration. Interview data could be gathered and compared across departments within the district to allow for an understanding of technology integration among the entire school system. In addition, interview data for middle and high school mathematics teachers could be gathered and compared across school systems to better understand the technology integration of this population in general. This study presents an initial look at the technology integration within a particular school system among a specific population of teachers and the results may offer a baseline for future research, which is further discussed later in this chapter.

Main Research Question

The main research question asked: In what ways do secondary mathematics teachers' use of technology in the classroom reflect their attitudes towards technology and its use? The overall mean scores on the TAC questionnaire for the interview participants were found to range from 3.53 to 4.72, which fell in the Somewhat High and Very High categories for the intervals of the mean scores. The combined overall mean score (*M* = 4.04) of this group was in the Somewhat High category, as five of the individual overall mean scores were in the Somewhat High category and three were in the

Very High category. The overall median score (*Mdn* = 3.95) of this group was also in the Somewhat High category. This indicates that those teachers willing to be interviewed had relatively positive attitudes towards technology. The quantitative results for this group of interviewees are similar to the results for the whole group of participants as the mean and median of both groups fell in the Somewhat High category. In addition, both groups had the lowest mean scores in absorption and interaction and the highest mean score in accommodation.

The higher percentage for using technology for instructional methods reflects the participants' positive attitudes toward technology, especially with regard to accommodation. These teachers indicate positive feelings towards adapting to the use of computers in the workplace and life in general. Those feelings may encourage their own use of technology in the classroom. The teachers demonstrate a willingness to adapt to using technology in their own work activities but seem to struggle more with adapting to using technology in more student-centered activities. The lower percentage for using technology for student learning processes shows their less positive attitudes, especially concerning absorption and interaction.

The less positive attitude regarding interaction may be a result of the focus on email as the means for interacting. Since the students in the district do not have access to an institutional email account, the responses may be low as a result. Absorption deals with how the participant spends their time, the level of engagement they have with computers. Teachers may feel that they do not have enough time to spend with the technology to feel comfortable integrating it in student-centered activities. In addition to its effect on technology integration, this first order barrier may also have an effect on the teachers' attitudes (Leggett & Persichitte, 1998; Ertmer, 1999; Vongkulluksn et al., 2018). The participants' low mean score in comfort also supports this idea. The lower percentage for using technology for curriculum goals also shows their less positive attitudes, especially with regard to concern and absorption. Teachers may be hesitant to use technology for curriculum goals because they may be concerned about the reliance on technology to meet curriculum goals or they do not have the time to engage with technology in that way so they can fully understand how technology can be used to meet curriculum goals.

The majority of technology use was coded as amplification, which reflects the participants' high scores in utility and significance. Teachers displayed a positive attitude toward the usefulness of technology and placed a high value on the use of technology in education, the workplace, and society. Since a positive attitude was shown towards the utility of technology, it makes sense that teachers would be using it to amplify their educational activities rather than just replacing them. This positive attitude toward the value of technology may motivate teachers to overcome their belief about their skills for the good of their students (Vongkulluksn et al., 2018). The tendency to integrate technology at the amplification level more than the replacement or transformation level is common among K-12 teachers (Blanchard et al., 2016; Hughes et al., 2017). The lack of frequencies coded as transformation reflects the less positive attitudes regarding comfort and concern. Teachers showed a less positive attitude with regard to their own comfort level with technology and concern about the effects of technology on individuals and society. Teachers may be apprehensive to transform a classroom activity such that it is fundamentally changed because they are uncomfortable with the change or are concerned about potential negative effects of the transformation.

This study shows that the attitudes of teachers toward technology are reflected in the ways they use technology in the classroom. The constructs in which teachers had more positive attitudes correlate to their frequent use of technology for instructional methods and as amplification, while the constructs in which teachers had less positive attitudes correlate to their less frequent use of technology for student learning purposes and curriculum goals and as transformation. As Challoo, Green, and Maxwell (2010) found, using the TAC questionnaire, the level of technology integration is influenced by the attitudinal constructs. This is also consistent with the findings of Petko (2012), that a significant positive correlation between teachers' beliefs about the effectiveness of technology and its use in the classroom exists.

Implications

The findings of this study contribute to the existing research regarding teachers' attitudes towards technology and their use of technology in the classroom (Challoo et al., 2010; Ertmer et al., 2012; Kim et al., 2013; Petko, 2012). The teachers in this study report attitudes similar to the findings of Ertmer (2012) which found that the majority of teachers feel "somewhat well-prepared" to use technology for classroom instruction and most have a desire to learn how to integrate technology into their classrooms. These results also seem to align with those of Yu (2012), who found that many teachers are enthusiastic and optimistic about technology. They believe that the more technological knowledge they have, the more likely they are to integrate it in their classrooms.

This study demonstrates that the teachers could have positive attitudes towards technology but may not be integrating it into their classrooms as effectively as they believe. As the results reflect, teachers are using technology in a more teacher-centered manner. As Norton, McRobbie, and Cooper (2000) suggest, those who have a teacher-centered pedagogical style use technology for computational and other low level activities, while those with a learner-centered style use technology to “construct mathematical meaning and explore the fallible nature of mathematics” (p. 105). To encourage a more student-centered approach, district leaders may want to consider providing professional development activities that focus on using technology in student-centered pedagogical approaches to foster less teacher-centered and more student-centered learning environments (Ramírez et al., 2012). Leaders may also want to consider an “innovatory” approach to professional development by providing equipment and support, technical and pedagogical, for all participants in a department or school and introducing appropriate learning styles and interactive learning methods as whole school policies (Glover & Miller, 2007).

In addition, assessing teachers’ attitudes towards technology before and after professional development on technology integration may show an increase in positive attitudes as a result of the in-service activities as Hartsell, Herron, Fang, and Rathod (2010) found in their study. Leaders may also want to consider the frequency and length of professional development with technology. Gningue (2003) found that professional development that spans a longer time frame and is held more frequently is more effective in improving teachers’ attitudes towards technology than just a few sessions. A professional development plan that includes long-term training may have a greater impact on the teachers' attitudes towards technology than one with short-term training.

As Leggett and Persichitte (1998) found, time is a barrier to teachers' integrating technology in the classroom. Providing teachers with time to learn new technologies and integration strategies may increase the likelihood of classroom integration. Although teachers may believe that technology has positive benefits for their students, teachers need to spend time with the technology themselves before trying to integrate it into the classroom in order to feel comfortable (Constantine et al., 2017). During professional development, leaders may want to incorporate time for their teachers to become comfortable with using technology in the classroom.

By using the RAT model as a framework for examining the use of technology in the classroom, this study also contributes to the collection of research using the model (Ardic & Isleyen, 2017; Blanchard et al., 2016; Bozkurt et al., 2014; Hsieh & Tsai, 2017; Hughes et al., 2017; Mishra et al., 2016; Stockero et al., 2011). This study showed that the participants used technology mostly for amplification with some replacement but no transformation. The findings of Ardic and Isleyen (2017) may also apply to the teachers in this study. After professional development that focuses on technology integration, teachers may shift from integrating technology in the classroom at the replacement and amplification levels to integrating it more at the amplification and transformation levels. Teachers may also be encouraged by the findings of Killion (2016) that, as secondary teachers increase technology integration in their classrooms and move across the continuum from replacement to transformation, students are reaping the benefits of high achievement, particularly in math and science.

Recommendations for Future Research

Due to the specific nature of the population of this study, it is recommended that future studies in the district be conducted that widen the population depending on the focus of the study. The population could include all secondary teachers to focus on teachers' attitudes and technology integration across content areas at the middle and high school grade levels. However, if the focus is on teachers' attitudes and technology integration in the mathematics classroom, the population could be expanded to include all mathematics teachers in the district. This could provide the district leaders with information about their teachers' attitudes towards technology and their technology integration in order to plan professional development.

In addition, it is recommended that future research studies include the administration of the questionnaire to assess attitudes before and after a long-term professional development plan for technology integration has been implemented. For example, at the beginning of a school year, a potential study could assess teachers' attitudes toward technology through a questionnaire and interview teachers about their needs regarding technology integration in the classroom. Then, a series of professional development sessions regarding technology integration could take place throughout the school year providing teachers with time to learn and implement technological strategies in the classroom. At the end of the year, teachers' attitudes could be reassessed and follow-up interviews regarding technology integration conducted to determine if their needs had been addressed. The results could be compared to the previous results to determine if the professional development helped to improve attitudes and technology integration.

To allow for the expansion of the research base, it is recommended that further studies be conducted that include mathematics teachers from multiple school systems across the region or the country to provide a broader view of teachers' attitudes towards technology and their integration. A larger sample from a wider geographic area may provide more diversity in the data and may provide more insight on a grander scale.

Limitations

The original design of the study was to compare the technology integration of two groups of teachers with differing attitudes towards technology. The quantitative data, which shows the teachers' attitudes toward technology, was to be used to identify the group in which each participant would be placed. Then the qualitative data, which shows how teachers use technology in their classrooms, would be collected. Finally, the data would be combined to compare and contrast the use of technology between the two groups. However, the quantitative data in this study did not indicate two distinct groups. Therefore, the method was changed to eliminate a comparison between two groups and the data were combined as one whole group.

As this study included secondary mathematics teachers in a small, rural school district in Maryland, the sample was small and not randomized. Therefore, the study was limited to the teachers who were willing to participate in one or both phases of the study. The questionnaire was distributed during the first week teachers returned from summer break. Some teachers may have chosen not to participate in the quantitative phase because they felt that they did not have the time to spare. It is also possible that teachers who feel less comfortable with technology may have chosen not to participate in the qualitative phase of the study or not to participate at all. In addition, the school district was in the process of implementing a new learning management system at the time of the data collection. This change could have had an impact on the attitudes toward technology, especially regarding comfort and absorption.

The results of this study cannot be used to make generalizations, as the sample was small and not randomized. Therefore, other content areas, grade levels, or school districts should not apply these results to their population because the study is specific to a sample of secondary mathematics teachers in this small, rural school system.

This study is also limited by the fact that the researcher is a high school mathematics teacher in the school system being studied. As a colleague of the participants, the research is an insider (Merton, 1972). This may allow the researcher to have a better understanding of the issues and context of the study, as well as an established rapport with the participants, potentially causing them to be more open in their responses (Saidin & Yaacob, 2016). However, due to the researcher being an insider, the participants may have made assumptions about the researcher's knowledge of their curriculum and classroom practices and, therefore, may not have provided as much depth in their responses.

Conclusion

The findings of this study indicate that the attitudes towards technology of secondary mathematics teachers in the small, rural school district in the Mid-Atlantic region of the United States are reflected by their use of technology in the classroom. All of the participants' scores for the constructs of interest, comfort, accommodation, interaction, concern, utility, perception, absorption, and significance were examined in the quantitative phase of the study. A self-selected subset of the participants was interviewed about their use of technology in the classroom in the qualitative phase with the RAT model used as the framework for analysis. The results were combined by reviewing the quantitative data of the subset in light of the qualitative data. The constructs in which teachers had more positive attitudes are reflected by their frequent use of technology for instructional methods and as amplification, while the constructs in which teachers had less positive attitudes are reflected by their less frequent use of technology for student learning purposes and curriculum goals and as transformation.

As the use of technology in the classroom continues to increase, improving teachers' attitudes towards technology and providing professional development to increase teachers' knowledge and comfort with technology should be a priority of school system leaders. By providing learning opportunities and time to practice, leaders will demonstrate their understanding of the needs of teachers in order to be effective integrators of technology in their classrooms. While teachers vary in their attitudes towards technology, knowledge of technological and pedagogical strategies, and technological skills, providing opportunities for each individual to grow will show a common respect for all teachers regardless of personal attitudes, knowledge, or skill level.

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APPENDIX A

Teachers' Attitudes Toward Computers Questionnaire

Demographic Information

Years of Experience:

- 0 - 4 years
- 5 - 10 years
- 11+ years

Grade level:

- Middle school
- High school

This questionnaire is derived from well-validated portions of several attitudinal surveys that have been used with teachers in the past. We will use your responses to help develop a profile of how teachers view technology. Please complete all items even if you feel that some are redundant. This should require about 10 minutes of your time. Usually it is best to respond with your first impression, without giving a question much thought. Your answers will remain confidential.

Part 1

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. I think that working with computers would be enjoyable and stimulating.
2. I want to learn a lot about computers.
3. The challenge of learning about computers is exciting.
4. I like learning on a computer.
5. I can learn many things when I use a computer.

Part 2

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. I get a sinking feeling when I think of trying to use a computer.

2. Working with a computer makes me feel tense and uncomfortable.

3. Working with a computer makes me nervous.

4. Computers intimidate me.

5. Using a computer is very frustrating.

Part 3

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. If I had a computer at my disposal, I would try to get rid of it.

2. Studying about computers is a waste of time.

3. I can't think of any way that I will use computers in my career.

4. I will probably never learn to use a computer.

5. I see the computer as something I will rarely use in my daily life.

Part 4

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. The use of electronic mail (E-mail) makes the student feel more involved.

2. The use of E-mail helps provide a better learning experience.

3. The use of E-mail makes a class more interesting.

4. The use of E-mail helps the student learn more.

5. The use of E-mail increases motivation for class.

Part 5

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. Computers are changing the world too rapidly.
2. I am afraid that if I begin to use computers I will become dependent upon them.
3. Computers dehumanize society by treating everyone as a number.
4. Our country relies too much on computers.
5. Computers isolate people by inhibiting normal social interactions among users.
6. Use of computers in education almost always reduces the personal treatment of students.
7. Computers have the potential to control our lives.
8. Working with computers makes me feel isolated from other people.

Part 6

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. Computers could increase my productivity.
2. Computers can help me learn.
3. Computers are necessary tools in both educational and work settings.
4. Computers can be useful instructional aids in almost all subject areas.
5. Computers improve the overall quality of life.
6. If there was a computer in my classroom it would help me to be a better teacher.
7. Computers could enhance remedial instruction.
8. Computers will improve education.

Part 7

Instructions: Choose one location between each adjective pair to indicate how you feel about computers.

Computers are:

1. unpleasant 1 2 3 4 5 6 7 pleasant

2. suffocating 1 2 3 4 5 6 7 fresh

3. dull 1 2 3 4 5 6 7 exciting

4. unlikable 1 2 3 4 5 6 7 likeable

5. uncomfortable 1 2 3 4 5 6 7 comfortable

Part 8

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. I like to talk to others about computers.

2. It is fun to figure out how computers work.

3. If a problem is left unsolved in a computer class, I continue to think about it afterward.

4. I like reading about computers.

5. The challenge of solving problems with computers does not appeal to me.

6. When there is a problem with a computer that I can't immediately solve, I stick with it until I have the answer.

Part 9

Instructions: Select one level of agreement for each statement to indicate how you feel.

1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree

1. It is important for students to learn about computers in order to be informed citizens.

2. All students should have an opportunity to learn about computers at school.

3. Students should understand the role computers play in society.

4. Having computer skills helps one get better jobs.

5. Computers could stimulate creativity in students.

APPENDIX B

Interview Questions

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies—that is, the digital tools we use, such as computers, laptops, iPods, handhelds, interactive whiteboards, computer software programs, graphing calculators, etc.

Interview Questions

What grade levels and/or course or courses do you teach?

How do you use technology for planning lessons?

How do you use technology for instruction?

How do you use technology for assessment?

How do your students use technology for learning?

How do your students use technology for assessment?

Does your curriculum require the use of technology? If so, how.